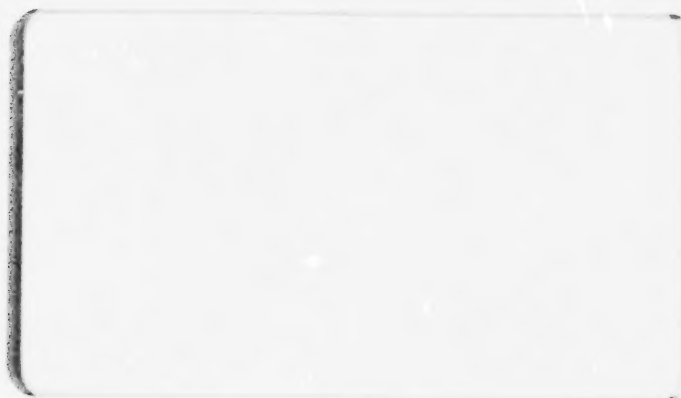


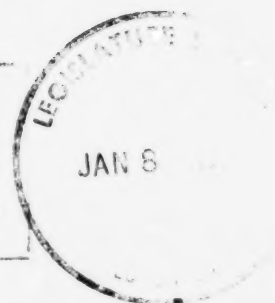
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WILLOW CREEK BASIN
HYDROLOGIC ASSESSMENT OF RESERVOIR ALTERNATIVES

Hydrology Branch
Technical Services Division
Water Resources Management Services
Alberta Environment

WILLOW CREEK BASIN

HYDROLOGIC ASSESSMENT OF RESERVOIR ALTERNATIVES

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Submitted by: A.M. Mustapha, P. Eng.

NOVEMBER 1985

1. BACKGROUND

Regional planning studies completed in the mid-seventies indicated that, with the present growth rate of water demands in the Willow Creek Basin, difficulties would be experienced in meeting these demands about the mid-eighties. Detailed studies were therefore recommended to develop a water resource management strategy for the Basin.

The low runoff volumes of the 1977 and 1984 growing seasons coupled with the high demands on the resource produced severe water shortages throughout the lower reaches of the basin. The growing season of 1985 is evolving into a similar predicament.

In response to the Willow Creek Watershed Committee, the Minister of Environment authorized, in October 1984, water storage feasibility studies of the Willow Creek Basin. In response to the Minister's request, Planning Division has coordinated activities to facilitate the investigative studies. Within the context of these studies, Technical Services Division was requested to derive natural flows in the basin, derive flood hydrographs for design purposes, and to obtain storage draft curves for potential storage sites under investigation.

This report provides the assessment of the several storage alternatives in the Willow Creek Basin and the resulting storage draft curves, as requested by Planning Division.

1.1 OBJECTIVE

At the request of Alberta Environment's Planning Division, Hydrology Branch of Technical Services Division was to provide a water supply assessment for each of the identified storage alternatives, given a set of monthly agricultural demands.

SYNOPSIS

An hydrologic assessment was performed on four reservoir alternatives in the Willow Creek Basin. The assessment was based on the effects of the reservoirs on the monthly streamflow data of the Willow Creek Basin for the period 1912 to 1983. Three independent options were examined for each alternative. The first option represented those optimum conditions for which agricultural demands were met with 100 percent reliability for the period of record. The second and third options represented those conditions for which 95 percent and 90 percent reliability rates occurred, respectively.

Two computer models were developed to assist in the assessment. The assumptions, procedures, and results of the models are presented and discussed. The overall results, summarized as storage-draft curves, are also included.

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Specifically, this study includes:

- a) the identification of several storage options,
- b) the description of use of the generated streamflow data base,
- c) the description of reservoir operation procedures, including the development of computer programs, to simulate the effects of each storage option on natural flows,
- d) the description of the methodology used in deriving storage-draft curves,
- e) the resulting storage-draft curves of each tested storage option, and
- f) the interpretation and assessment of results.

2. COMPILATION OF DATA

Prerequisite to the assessment of alternatives was the compilation of data with regards to: (i) the physical characteristics of each alternative, (ii) the generated streamflows of the basin, and (iii) the operation procedures for the reservoirs. Details of these data are described in the following subsections.

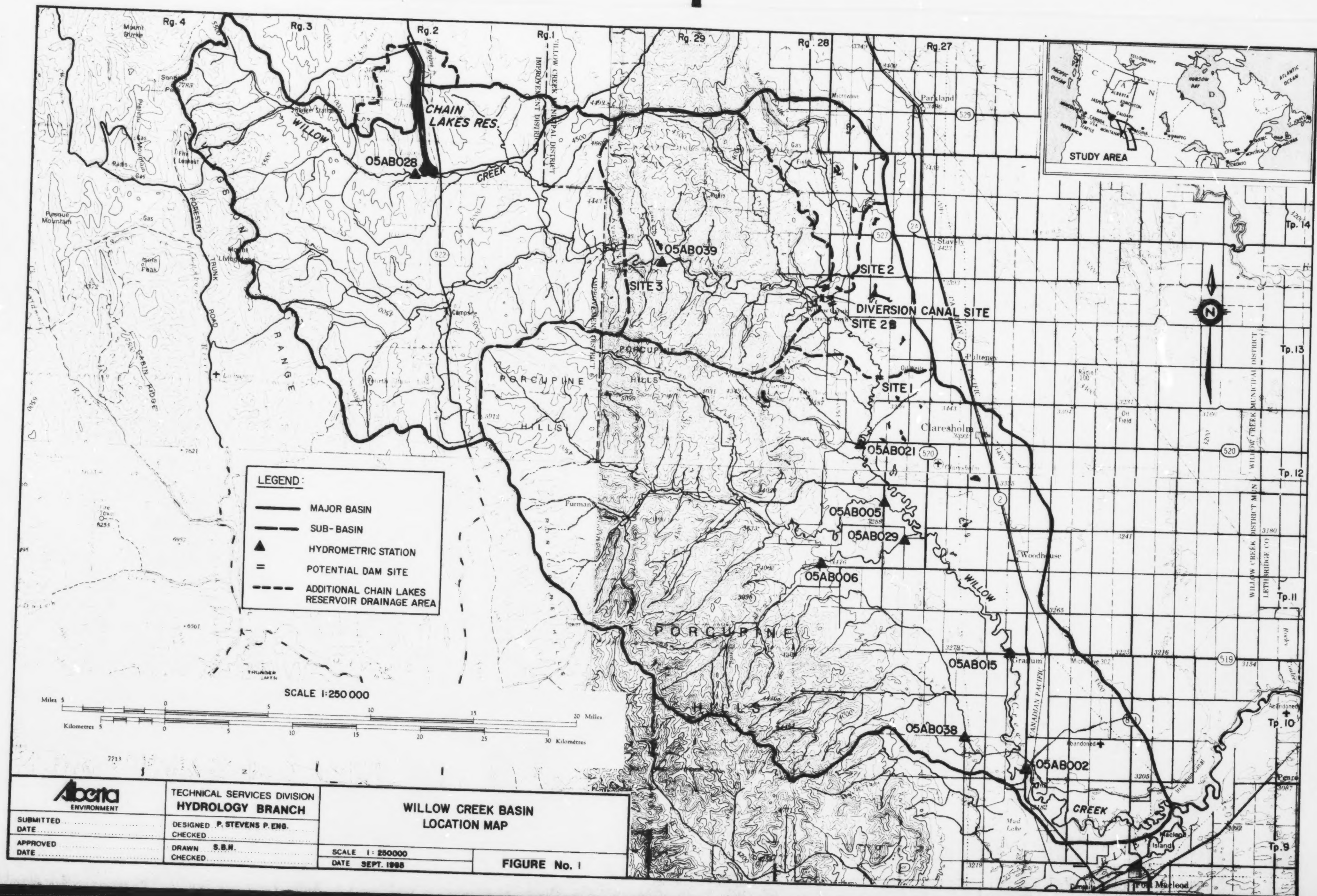
2.1 IDENTIFICATION OF ALTERNATIVES

With the direction of Planning Division and communications with Design and Construction Division, three potential reservoir sites were identified. The three potential reservoir sites, along with existing conditions, form the four water management alternatives analyzed in this report. Table 2.1 provides a summary of the four alternatives. The locations of the reservoir sites are shown in Figure 1.

Alternative A1 involved the assessment of the basin under existing conditions of storage capacity. The results of this alternative provided an indication of the yield for various levels of efficiency which could be obtained if the existing Chain Lakes Reservoir, without additional storage in the basin, were used to meet agricultural demands. The outflows computed for this alternative were not expected to coincide with the respective recorded flows since, historically, the operation of the Chain Lakes Reservoir was on an ad hoc basis, dependent primarily upon downstream municipal demands. The operation of the modelled reservoir for Alternative A1 was based on the assumption of predetermined demands, which were fixed for each year. These demands were quantified by Planning Division and are described in more detail in subsection 3.5 of this report.

Table 2.1: Inventory of Reservoir Alternatives

Alternative	Site #	Name	Description
A1	--	Chain Lakes Reservoir	Chain Lakes Reservoir only
A2a	2	Pine Coulee Offstream Reservoir	Offstream Storage in Pine Coulee, in conjunction with Chain Lakes Reservoir. Diversion Canal Capacity = 300 cfs
A2b	2	Pine Coulee Offstream Reservoir	As A2a; Diversion Canal Capacity = 600 cfs
A2c	2	Pine Coulee Offstream Reservoir	As A2a; Diversion Canal Capacity = 900 cfs
A3	2	Pine Coulee Onstream Reservoir	Onstream Reservoir downstream of Pine Coulee and Willow Creek Confluence in conjunction with Chain Lakes Reservoir
A4	1	Claresholm Reservoir	Onstream Reservoir near Town of Claresholm, in conjunction with Chain Lakes Reservoir



Alternative A2 involved both the Chain Lakes Reservoir and the Pine Coulee Offstream Reservoir (also referred to as Site #2). In this alternative, Chain Lakes Reservoir was required to supply a base flow during the winter months only, while the reservoir in Pine Coulee was required to supply all other flow requirements throughout the year. Since local runoff from Pine Coulee is relatively insignificant, the reservoir storage would be supplemented by means of a canal which diverts excess flows from Willow Creek to Pine Coulee. In this regard, three canal capacities were assessed. Alternative A2a included a diversion capacity of 300 cubic feet per second (cfs); Alternative A2b included a diversion capacity of 600 cfs; Alternative A2c included a diversion capacity of 900 cfs.

Alternative A3 involved Chain Lakes Reservoir and the Pine Coulee Onstream Reservoir (also referred to as Site #2). As in Alternative A2, Chain Lakes Reservoir was required to supply a winter base flow, while the Pine Coulee Onstream Reservoir was required to supply all other flow requirements throughout the year.

Alternative A4 involved Chain Lakes Reservoir and the Claresholm Reservoir (also referred to as Site #1). As in Alternative A2, the Chain Lakes Reservoir was required to supply a winter base flow, while the onstream Claresholm Reservoir was required to supply all other flow requirements throughout the year.

2.2 PHYSICAL CHARACTERISTICS OF THE RESERVOIRS

At the present time, a single reservoir exists in the Willow Creek Basin, that being the Chain Lakes Reservoir. Four additional sites for reservoirs have been identified elsewhere in the basin, and are shown in Figure 1. At the present time, detailed surveys and topographical maps had been finalized for three of the sites, namely Alternatives A2 (Site #2), A3 (Site #2b) and A4 (Site #1). Without the detailed surveys and topographical maps for the fourth site (Site #3), a hydrologic assessment of that site would necessarily be less definitive than the other alternatives and therefore could prove difficult for comparative purposes. Therefore Site #3 was not assessed at this time.

Elevation-area-capacity relationships of each reservoir were produced by Hydrology Branch, using 1:2000 topographical maps having 2.5 meter contour intervals provided by Survey Branch of Technical Services Division. Maximum potential storage levels due to topographic limitations, Permanent Pool Storage and diversion canal capacities, were obtained from Design and Construction Division. A summary of the physical characteristics of the existing and proposed reservoirs used in the assessments are presented in Table 2.2. Area capacity curves of the four reservoirs are presented in Figure 2 through 5.

2.3 TESTED OPTIONS

The water management alternatives identified in Section 2.1 were evaluated at various levels of storage up to the topographical Maximum Potential Storage Level, MPSL, (of each of the proposed reservoirs), in order to determine the reservoir yield to storage volume ratio. The reservoir yield, in excess of winter base flow (which in all alternatives was supplied by the existing Chain Lakes Reservoir), was assessed for three storage options of acceptable reliability. The three tested options of acceptable reliability were the 100%, 95%, and 90%. The 100% option represented the condition for which there were no failures in meeting the May through October monthly demand for the 72 years of record. The 95% option represented the condition for which successes in meeting the monthly demand occurred in all months for 95% of the May through October 72 years of record. The 90% option represented the condition for which successes in meeting the May through October monthly demand occurred in all months for 90% of the 72 years of record. A success was defined as a resultant flow which was at least 90% of the demand flow for each month of the year. A failure was defined as a resultant flow which was less than 90% of the demand flow for at least one month in the year. A summary of the tested options is presented in Table 2.3. A graphical description of these terms is provided in Figure 6.

Table 2.2: Physical Characteristics of Reservoirs

Reservoir	G.S.C. Elevation Feet	Surface Area Acres	Reservoir Capacity Acre-Feet	Source of Information*	Other*
Chain Lakes	4222.5	0	0	W.E.R.	
	4234.5	320	1200		Permanent Pool
	4238.0	430	2200		Storage = 1200 ac.ft.
	4241.0	540	3400		(W.E.R.)
	4245.0	620	5400		F.S.L. = 4255.5 ft.
	4248.0	670	7400		(W.E.R.)
	4251.0	720	9640		
	4255.5	770	13000		
Pine Coulee Offstream	3390.0	0	0	HYD.	
	3395.6	77	318		Permanent Pool
	3403.8	250	1661		Storage = 11000 ac.ft.
	3412.0	360	4165		(D.&C.)
	3420.2	501	7698		M.P.S.L. = 3453.1 ft.
	3428.4	711	12669		(D.&C.)
	3436.6	911	19320		Diversion Canal
	3444.8	1189	27931		Capacity Ranging
	3453.1	1386	38490		From 300 cfs to
	3461.2	1596	51719		900 cfs (HYD.)
Pine Coulee Onstream	3379.3	0	0	HYD.	
	3387.5	33	137		Permanent Pool
	3395.7	180	1011		Storage = 11000 ac.ft.
	3403.9	382	3315		(D.&C.)
	3412.1	528	7018		M.P.S.L. = 3453.1
	3420.3	727	12197		(D.&C.)
	3428.5	1018	19356		
	3436.7	1305	28882		
	3444.9	1708	41237		
	3453.1	2091	56818		
	3461.3	2485	75588		
Claresholm	3308.7	0	0	HYD.	
	3313.6	13	50		Permanent Pool
	3321.9	105	483		Storage = 5000 ac.ft.
	3330.1	229	1852		(D.&C.)
	3338.3	391	4393		M.P.S.L. = 3379.3
	3346.5	501	8051		(D.&C.)
	3354.7	573	12459		
	3362.9	712	17734		
	3371.1	832	24070		
	3379.3	1036	31731		

* D. & C. = Design and Construction Division, Alberta Environment
 HYD. = Hydrology Branch, Technical Services Division, Alberta Environment
 W.E.R. = Reference 4
 F.S.L. = Full Supply Level
 M.P.S.L. = Maximum Potential Storage Level

MICROFILM DATE

DRAWING NO

FILE NO

FLOODED AREA (ACRES)

1000

900

800

700

600

500

400

300

200

100

0

FULL SUPPLY LEVEL = 4255.45 FT.

4260

4255

4250

4245

4240

4235

4230

4225

4220

RESERVOIR ELEVATION (FEET, GSC)

CAPACITY

PERMANENT POOL LEVEL = 4234.5 FT.

AREA

20000

18000

16000

14000

12000

10000

8000

6000

4000

2000

0

RESERVOIR CAPACITY (ACRE - FEET)



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HYDROLOGY BRANCH

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DATE NOV, 1985

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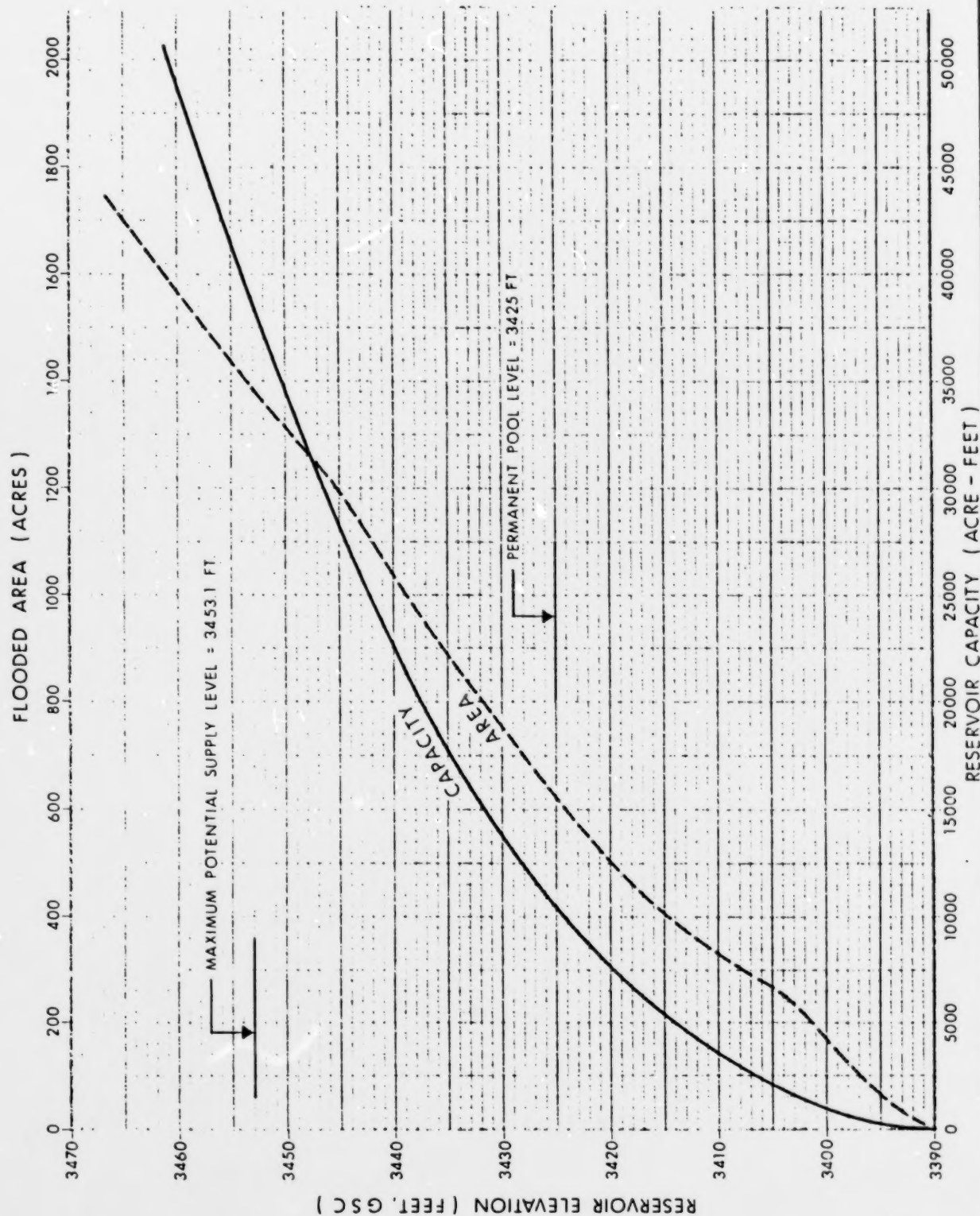
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DATE NOV, 1985

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AREA CAPACITY CURVES
ALTERNATIVE A1: CHAIN LAKES RESERVOIR

SCALE AS SHOWN
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FIGURE No. 2



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AREA CAPACITY CURVES
ALTERNATIVE A2 : PINE COULEE
OFFSTREAM RESERVOIR

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SCALE AS SHOWN
DATE NOV, 1985

FIGURE No. 3

FILE NO. _____

DRAWING NO. _____

MICROFILM DATE _____

FLOODED AREA (ACRES)

0 200 400 600 800 1000 1200 1400 1600 1800 2000

RESERVOIR ELEVATION (FEET, G.S.C.)

3500

3480

3460

3440

3420

3400

3380

3360

CAPACITY

AREA

MAXIMUM POTENTIAL SUPPLY LEVEL = 3453.1 FT.

PERMANENT POOL LEVEL = 3418.5 FT.

RESERVOIR CAPACITY (ACRE- FEET)

0 10000 20000 30000 40000 50000 60000 70000 80000 90000 100000



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AREA CAPACITY CURVES
ALTERNATIVE A3 : PINE COULEE
ONSTREAM RESERVOIR

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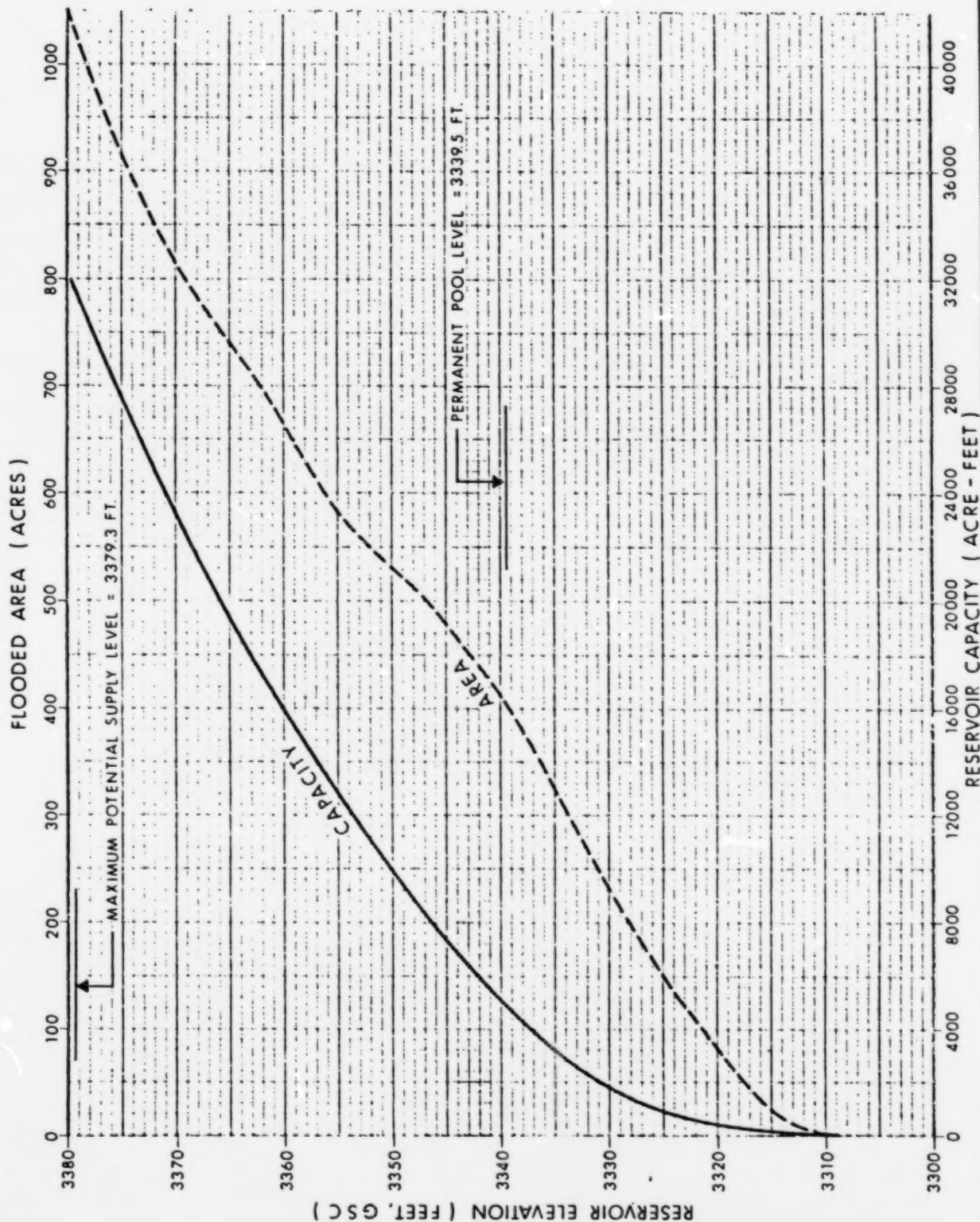
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FIGURE No. 4



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AREA CAPACITY CURVES

ALTERNATIVE A4: CLARESHOLM RESERVOIR

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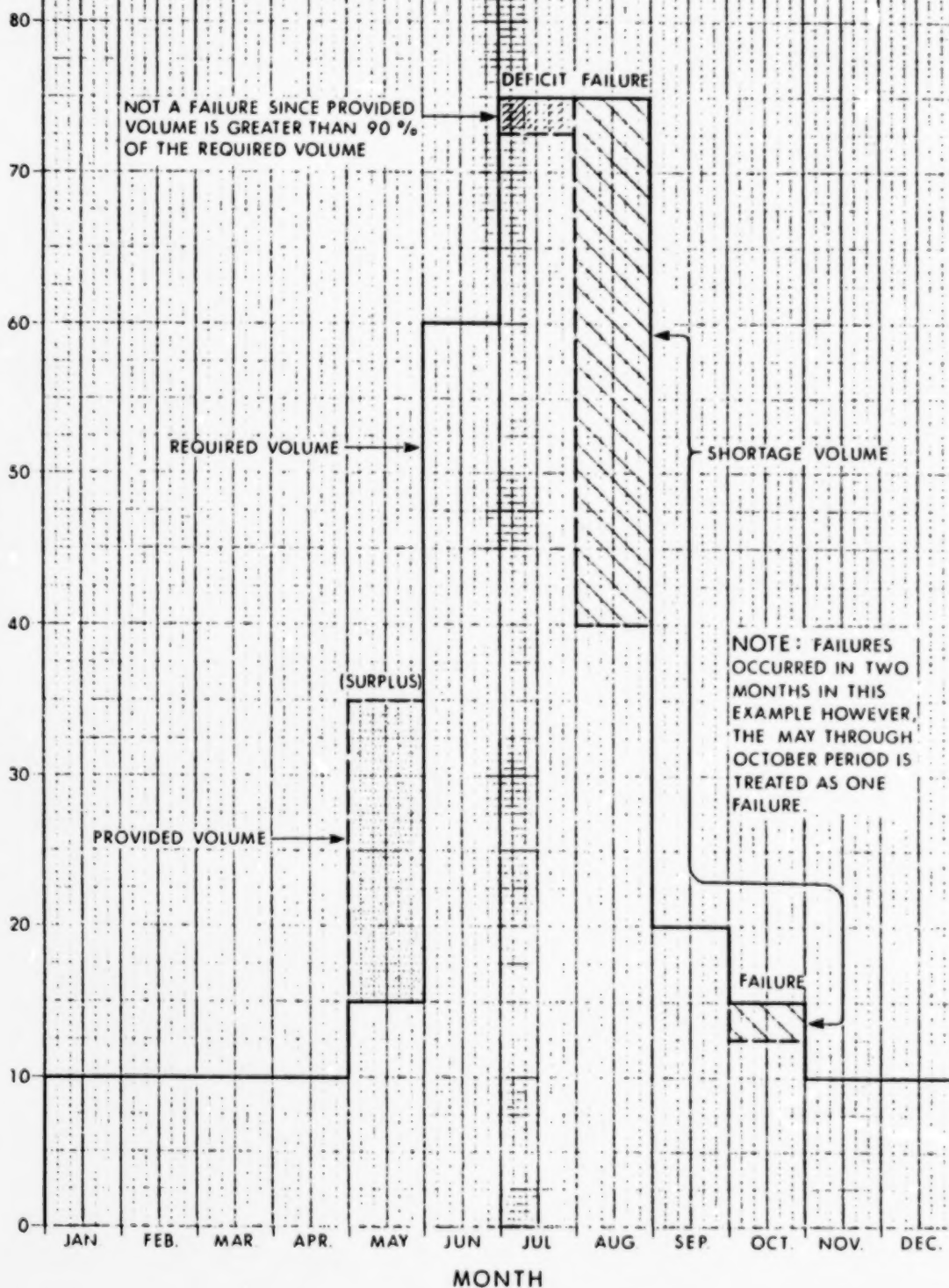
FIGURE No. 5

Table 2.3: Summary of Tested Options

Option Code	Description		Reliability %
	Reservoir Supplying Winter Base Flow	Reservoir Supplying May through October Demand	
100-A1	Chain Lakes	Chain Lakes	100
95-A1	Chain Lakes	Chain Lakes	95
90-A1	Chain Lakes	Chain Lakes	90
100-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	100
95-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	95
90-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	90
100-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	100
95-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	95
90-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	90
100-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	100
95-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	95
90-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	90
100-A3	Chain Lakes	Pine Coulee Onstream	100
95-A3	Chain Lakes	Pine Coulee Onstream	95
90-A3	Chain Lakes	Pine Coulee Onstream	90
100-A4	Chain Lakes	Claresholm	100
95-A4	Chain Lakes	Claresholm	95
90-A4	Chain Lakes	Claresholm	90

*DIVCAP - Diversion Canal Capacity

DISCHARGE (CFS)


Albera
 ENVIRONMENT

 TECHNICAL SERVICES DIVISION
 HYDROLOGY BRANCH

GRAPHICAL DESCRIPTION OF TERMS

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 DATE NOV, 1985

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 CHECKED P. STEVENS P. ENG.

 SCALE AS SHOWN
 DATE NOV, 1985

FIGURE No. 6

2.4 HISTORICAL STREAMFLOW DATA

The capability of each alternative in supplying downstream demands was assessed using an historical period of monthly mean streamflows. Complete data sets of natural flows for the period 1912 to 1983 were produced for eleven subbasins in the Willow Creek Basin and are presented in the report by FIGLIUZZI (1985). However, the data sets could not be used as presented due to the difference in the assessed and historical operations of the Chain Lakes Reservoir and its influence on downstream flows.

The original data sets were therefore manipulated to represent the local flows contributed by each sub-basin. These data sets were determined by subtracting the streamflows of an upstream station from those of a downstream station. Numerous negative inflows resulted, although of small magnitude. No effort was made to eliminate the negative flows. A second modification entailed the inclusion of inflow due to the additional drainage area located immediately northwest of the Chain Lakes Reservoir. Inflows from the additional 27 km² were estimated by multiplying the flows of streamflow gauging station C5AB039, Willow Creek below Lane Creek (as presented in the report by FIGLIUZZI (1985)), by the drainage area ratio of the two basins: $27 \text{ km}^2 / 730 \text{ km}^2 = .037$. The pertinent data sets used in the assessment are presented in Appendix A.

2.5 OPERATIONAL PROCEDURES OF RESERVOIRS

As there exists a limited supply of streamflow, an operational procedure for the use of the resource was necessary. A priority sequence was developed to accommodate the decision making process of water usage.

For offstream storage alternatives (i.e., Pine Coulee Offstream Reservoir) the following priority sequence was adopted.

For a given monthly volume:

1. Allow flow in Willow Creek to meet downstream demands; if streamflow volume is insufficient, release from reservoir, if possible.
2. If flow volume is in excess of downstream demands, the excess volume (to a maximum of the diversion capacity) is diverted to the reservoir to attempt to fill the reservoir to F.S.L. if not already at that level.
3. Any flow volume in excess of downstream demands and diversion capacity is lost downstream, unused.

For onstream storage alternatives (i.e., Chain Lakes, Pine Coulee Onstream, Claresholm Reservoirs), the following priority sequence was adopted.

For a given monthly inflow volume:

1. The total of the streamflow volume enters the reservoir.
2. If reservoir F.S.L. is exceeded, release excess water to meet F.S.L..
3. If downstream demands are not met with the excess water, release from reservoir, if possible.

3. WATER BALANCE SIMULATION

The repetitive nature of assessing a development alternative for each month of a 72 year period is ideally suited towards computer assisted analysis. A computer model was developed to simulate the effects of each type of reservoir: one for onstream storage; one for offstream storage. The effects of a proposed development option on pre-development flows were simulated purely on an accounting basis during discrete time intervals. Channel routing was not considered, implying that channel storage occurred neither during the month nor from one month to the next. On a monthly basis, this assumption does not bias the results in favor of any particular option. The listing of each model is provided in Appendix B.

One who is familiar with FORTRAN computer programming would be able to follow the logistics of the models. However, the implied assumptions are not immediately recognizable and are therefore stated explicitly below.

3.1 LOCAL INFLOWS

Data sets of local inflows used in the analysis are presented in Appendix A. Details of the production and modification to those data sets are outlined in Section 2.4 of this report.

3.2 OCCURRENCE OF ICE

Two types of ice formation were identified in this study: channel ice and reservoir ice.

The occurrence of ice in the river channel was accounted for implicitly via the streamflow data sets. Experience has shown that winter releases of 10 to 15 cfs from the Chain Lakes Reservoir result in streamflows of 3 to 5 cfs near Claresholm and are reflected in the data sets. A large percentage of these streamflow losses were due to the formation of channel ice. Identical losses due to ice formation were

assumed to have occurred for each scenario, therefore no adjustments were made to the data sets to account for the occurrence of ice formation in channels.

The occurrence of additional dead storage due to ice formation in reservoirs was treated separately. Ice thickness data collected from the Chain Lakes Reservoir were examined and a simplified schedule of ice thickness on reservoirs was used. It was assumed that: in November, 0.5 feet of ice thickness existed; December: 1.0 foot; January: 1.5 feet; February: 2.0 feet; March: 1.0 foot; April through October: no ice existed. The storage volume lost to ice formation in a particular month was calculated by multiplying the assumed ice thickness, in feet, by the surface area of the reservoir at the beginning of the month, in acres, yielding an ice volume, in acre-feet.

3.3 EVAPORATION AND PRECIPITATION

Since a new water body is introduced to the Willow Creek Basin in each development scenario, the effects of evaporation and precipitation on reservoir storage supplies are not reflected in the streamflow data sets. To account for the accumulation of precipitation in the reservoir, the monthly precipitation data set of Claresholm was used (from CARD (1982), Appendix 2). To account for the water deficit caused by evaporation, the completed monthly evaporation data set of Calgary was used (from CARD (1982), Appendix 3). An adjustment to the magnitude of the evaporation values was made, in accordance with Figure 2 of CARD (1982), Appendix 3, to accommodate for the difference in latitude and elevation between Calgary and each of the reservoir sites. Although no adjustment was made for the Chain Lakes Reservoir, the evaporation data set for each of the proposed reservoirs was obtained by increasing the Calgary data set by a factor of 1.025. The precipitation and evaporation data sets were summed to produce the net evaporation data set. The volume of water represented by the net evaporation was calculated by multiplying the net evaporation, in feet, by the surface area of the reservoir at the beginning of the month, in acres, to produce a net evaporation volume, in acre-feet.

During the winter season, precipitation normally falls as snow and evaporation is relatively small. In each model, the net evaporation for November through March was accumulated and then released in April.

3.4 SEEPAGE LOSSES

Seepage losses along Willow Creek were assumed to be identical for each scenario and therefore reflected in the produced streamflow data sets. No adjustments were made to the data sets to account for any possible changes in seepage losses.

Seepage losses in reservoirs were assumed to be negligible. During initial filling of a reservoir, losses due to seepage may in fact be significant although it is expected that seepage losses would be negligible in the long term.

3.5 DOWNSTREAM FLOW REQUIREMENTS

To assist in the assessment of alternative development options, monthly flow requirements downstream of the reservoir sites were estimated by Planning Division. A summary of the monthly requirements are presented in Table 3.1. The distribution of monthly demands in the Willow Creek Basin is presented graphically in Figure 7.

In this study, each option was assessed using two sets of demands: a set of fixed demands which were to be met by the Chain Lakes Reservoir, and a set of variable demands which were to be met by a downstream reservoir.

The fixed demands consisted of a constant 10 cfs from November through April, emanating from the south end of Chain Lakes Reservoir into Willow Creek and a constant 3 cfs throughout the year emanating from the north end of Chain Lakes Reservoir into Stimson Creek (outside Willow Creek Basin).

Table 3.1: Summary of Downstream Flow Requirements

=====					
Estimated Present Conditions			Proposed Requirements		
Chain Lakes Demand			Chain Lakes Reservoir Demand		Downstream Reservoir Demand
Month	Stimson Creek cfs	Willow Creek cfs	Stimson Creek cfs	Willow Creek cfs	cfs
Jan.	3	15	3	10	--
Feb.	3	15	3	10	--
Mar.	3	10	3	10	--
Apr.	3	10	3	10	--
May	3	5	3	--	15
June	3	5	3	--	60
July	3	5	3	--	75
Aug.	3	10	3	--	75
Sept.	3	10	3	--	20
Oct.	3	10	3	--	15
Nov.	3	15	3	10	--
Dec.	3	15	3	10	--
=====					

DEMAND (CFS)

80

70

60

50

40

30

20

10

0

JAN.

FEB.

MAR.

APR.

MAY

JUN.

JUL.

AUG.

SEP.

OCT.

NOV.

DEC.

MONTH

AGRICULTURAL DEMAND

(VARIABLE VOLUME)

MUNICIPAL DEMAND

(FIXED VOLUME)

MUNICIPAL DEMAND

(FIXED VOLUME)

Alberta
ENVIRONMENTTECHNICAL SERVICES DIVISION
HYDROLOGY BRANCHMONTHLY DEMAND DISTRIBUTION
IN THE WILLOW CREEK BASINSUBMITTED S. FIGLIUZZI, P. ENG.
DATE NOV., 1985DESIGNED P. STEVENS, P. ENG.
CHECKEDAPPROVED M. MUSTAPHA, P. ENG.
DATE NOV., 1985DRAWN V. DA SILVA
CHECKED P. STEVENS, P. ENG.SCALE AS SHOWN
DATE NOV., 1985

FIGURE No. 7

The variable demands were derived from the downstream reservoir demands presented in Table 3.1. The relative size of these demands (from May through October) remained fixed. However, the magnitude of the total demand was varied so as to obtain a failure rate approximating that of the scenario being investigated. For example, to determine the reliability of a reservoir having a May to October demand of 20,000 acre-feet, the demand was distributed on a monthly basis by multiplying the 20,000 acre-feet by each of the factors shown in the last column of Table 3.2 to arrive at the flow in cfs for each month. These numbers were input in the appropriate computer model to ascertain the reliability of the reservoir at the 20,000 acre-feet level of demand.

Table 3.2: Modelled Streamflow Demands

Month	Demand Requirements		
	Fixed (from Chain Lakes) North End to Stimson Creek (cfs)	South End to Willow Creek (cfs)	Variable* (for A Downstream Reservoir)
Jan.	3	10	
Feb.	3	10	
Mar.	3	10	
Apr.	3	10	
May	3		0.000948
Jun.	3		0.003790
Jul.	3		0.004739
Aug.	3		0.004739
Sep.	3		0.001261
Oct.	3		0.000948
Nov.	3	10	
Dec.	3	10	

* Multiply the May to October variable demand, in acre-feet, by each of the factors shown to obtain the monthly demand, in cfs.

3.6 PINE COULEE OFFSTREAM DIVERSION CANAL

Alternative A2 (Pine Coulee Offstream Reservoir) includes a canal which diverts streamflow from Willow Creek to the Pine Coulee Offstream Reservoir during the April through October period. Since the cost of the diversion canal was very sensitive to the capacity of the canal, a more detailed analysis of streamflow through the canal was required. A monthly time step did not adequately assess the effect of streamflow variability on the efficiency of the canal to divert the required volumes of water to the reservoirs. Considering that (a) much of the monthly streamflow data were generated through regression analysis and (b) (to a lesser extent) the cost of computer runs, the time step used to assess the diversion canal capacity was limited to five day intervals.

The magnitude of the five-day streamflow volumes were determined thus:

1. Each month was separated into six intervals: five 5-day intervals and the sixth interval ranged from three to six days, contingent upon the month.
2. Daily recorded data were averaged for each of the six intervals per month, for the period 1912 to 1983. Since no streamflow gauging station in the Willow Creek Basin existed for the entire period, several stations were utilized in attaining the five-day averages and are presented in Appendix C.
3. The monthly inflow available to the diversion canal was then distributed using the appropriate volumetric ratios.

4. RESULTS

The detailed output of each option is about 1000 lines long. Such an amount of output was considered too voluminous to be included in this report and would serve a limited usefulness. The detailed output was retained on file in Hydrology Branch.

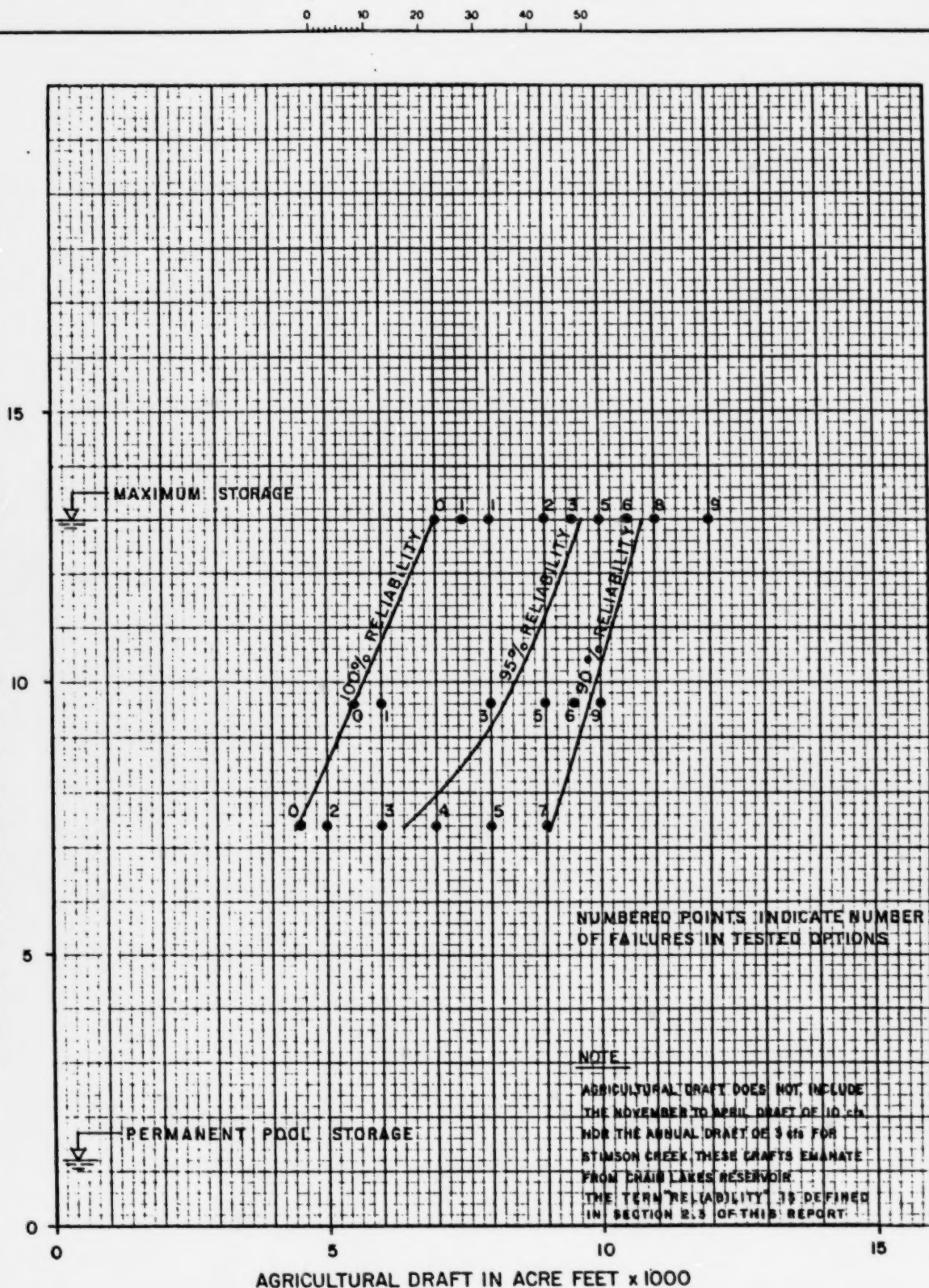
Storage draft curves for each of the alternatives were developed for options having 100, 95, and 90% reliabilities. The results for alternatives A1, A2, A3, and A4 are presented in Figures 8, 9, 10, and 11, respectively. As outlined in Section 2.3 a success in meeting the annual agricultural demand was considered to have occurred if the provided flow was at least 90% of the demand flow in all months during the May to October period of operation.

Detailed summaries, in terms of number of failures which would have occurred for each month and reservoir yield, for simulation runs which approximated the 100, 95, and 90% reliabilities at the topographical maximum storage level for each of the alternatives are presented in Table 4.1. Failures in winter months for alternatives A3 and A4 as indicated in Table 4.1 are not the results of Chain Lakes being unable to meet the winter flow requirements but rather are the combined result of both the downstream reservoir having been drawn down to the permanent pool level and production of surface ice on the reservoir. Table 4.2 provides further detail, in terms of both duration and severity of failures for the 100, 95, and 90% reliabilities at the topographical maximum storage level for each alternative. Table 4.2 may be read as follows; for option 95-A2a (that is, the Pine Coulee Offstream Reservoir, with a diversion canal capacity of 300 cfs and an acceptable reliability of 95% for the period of record), the system would have succeeded in supplying a firm yield of 25,500 acre-feet for about 95% of the years. More specifically, four years resulted in failures (1931, 1936, 1937 and 1944), the 1931 failure persisted for one month in October with the May through October shortage being 362 acre-ft or 2.2% of the annual draft. Table 4.3 provides further information in regards to duration and severity of failure to meet winter demand for the maximum development options and can be read in a similar fashion as Table 4.2.

MICROFILM DATE

DRAWING NO

RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 1200 ACRE FEET DEAD STORAGE)



FILE NO



TECHNICAL SERVICES DIVISION
HYDROLOGY BRANCH

STORAGE DRAFT CURVES
ALTERNATIVE A1: CHAIN LAKES RESERVOIR

SUBMITTED S.J. FIGLIUZZI, P. ENG.
DATE

DESIGNED P. STEVENS, P. ENG.
CHECKED

SCALE AS SHOWN
DATE SEPT. 1985

APPROVED A.M. MUSTAPHA, P. ENG.
DATE

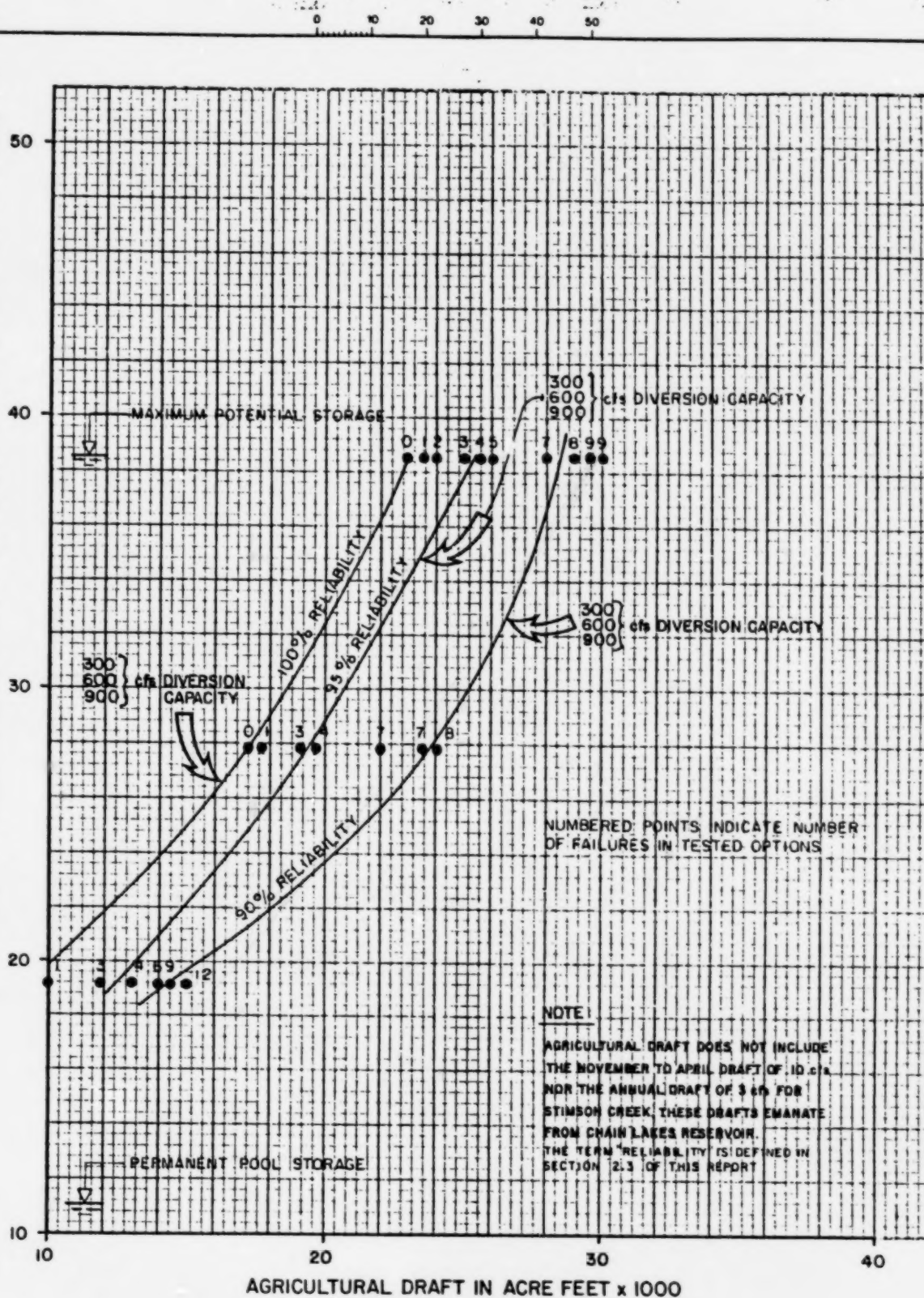
DRAWN I. LUKNAR
CHECKED P. STEVENS, P. ENG.

FIGURE No. 8

MICROFILM DATE

DRAWING NO

RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 11000 ACRE FEET DEAD STORAGE)


Albera
 ENVIRONMENT

 TECHNICAL SERVICES DIVISION
 HYDROLOGY BRANCH

 STORAGE DRAFT CURVES
 ALTERNATIVE A2: PINE COULEE RESERVOIR

 SUBMITTED S.J. FIGLIUZZI P.ENG.
 DATE

 DESIGNED P. STEVENS P.ENG.
 CHECKED

 APPROVED A.M. MUSTAPHA P.ENG.
 DATE

 DRAWN
 CHECKED P. STEVENS P.ENG.

 SCALE AS SHOWN
 DATE SEPT. 1985

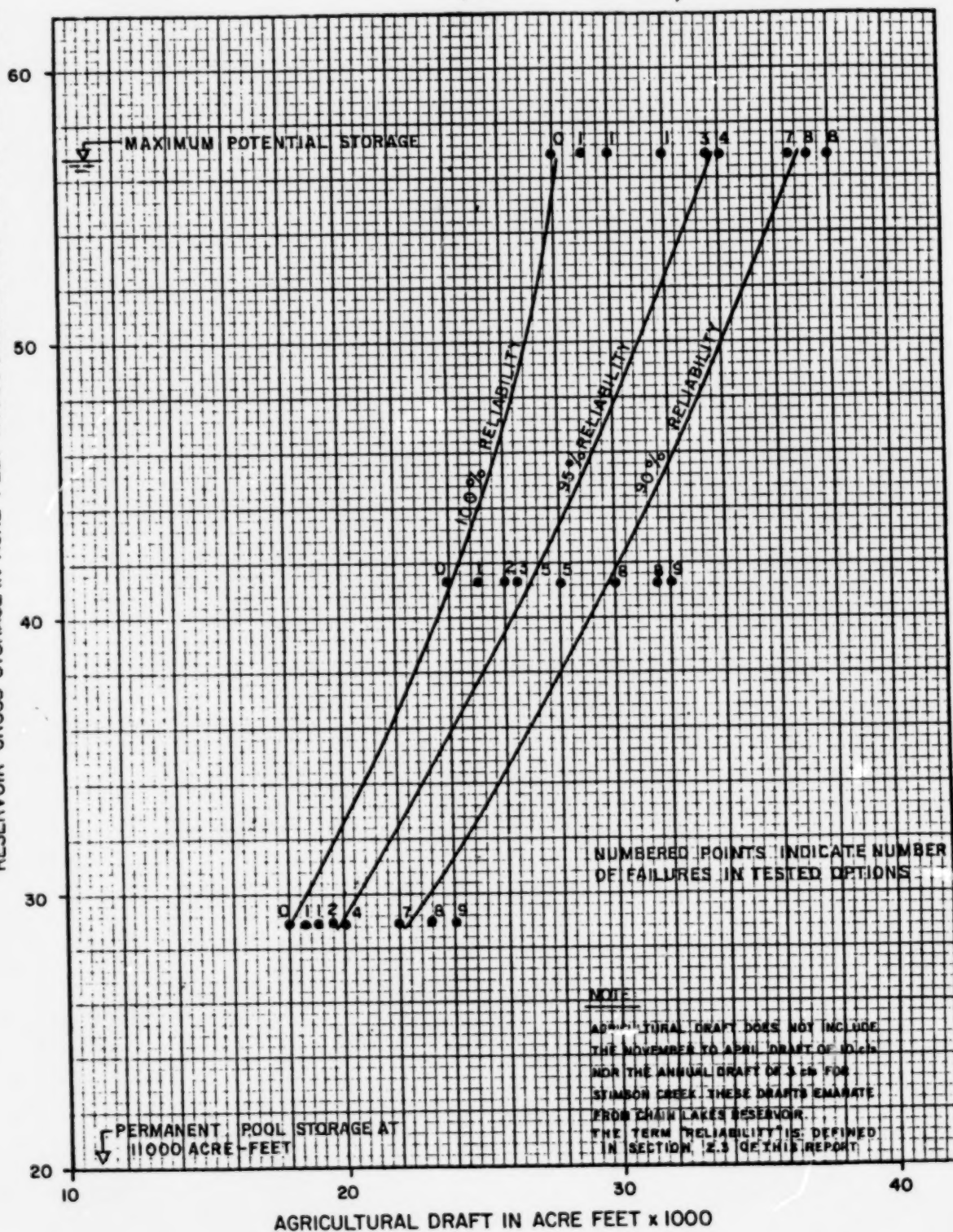
FIGURE No. 9

FILE NO

MICROFILM DATE

DRAWING NO.

RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 11000 ACRE FEET DEAD STORAGE)



TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH

STORAGE DRAFT CURVES ALTERNATIVE A3: PINE COULEE ONSTREAM RESERVOIR

 SUBMITTED S.V. FIGLIUZZI P. ENG.
 DATE

 DESIGNED P. STEVENS P. ENG.
 CHECKED

 SCALE AS SHOWN
 DATE SEPT. 1985

FIGURE No. 10

 APPROVED A.M. MUSTAPHA P. ENG.
 DATE

 DRAWN I. LUKNAR
 CHECKED P. STEVENS P. ENG.

FILE NO.

MICROFILM DATE

DRAWING NO.

RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 5000 ACRE FEET DEAD STORAGE)

40

30

20

10

0

MAXIMUM POTENTIAL STORAGE

PERMANENT POOL STORAGE

NUMBERED POINTS INDICATE NUMBER OF FAILURES IN TESTED OPTIONS

THE TERM "RELIABILITY" IS DEFINED IN SECTION 2.3 OF THIS REPORT

NOTE:

AGRICULTURAL DRAFT DOES NOT INCLUDE THE NOVEMBER TO APRIL DRAFT OF 10 cfs NOR THE ANNUAL DRAFT OF 3 cfs FOR STIMSON CREEK. THESE DRAFTS EMANATE FROM CHAIN LAKES RESERVOIR.

AGRICULTURAL DRAFT IN ACRE FEET x 1000



TECHNICAL SERVICES DIVISION
HYDROLOGY BRANCH

STORAGE DRAFT CURVES
ALTERNATIVE A4: CLARESHOLM RESERVOIR

SUBMITTED S.J. FIOGUZZI P. ENG.
DATE

DESIGNED P. STEVENS P. ENG.
CHECKED

APPROVED A.M. MUSTAPHA P. ENG.
DATE

DRAWN I. LUKNAR
CHECKED P. STEVENS P. ENG.

SCALE AS SHOWN
DATE SEPT. 1985

FIGURE No. 11

FILE NO.

Table 4.1: Reliability of Options

Option	Number of Failures in Month												Number of Years With at Least One Shortage in May to October Period	Basin Yield* acre-feet	Reliability %
	J	F	M	A	M	J	J	A	S	O	N	D			
100-A1		2	1										-	9600	100.0
95-A1	5	7	3										3	13100	95.8
90-A1	9	9	4				1	2	3	3	4	5	7	14600	90.3
100-A2a													-	26600	100.0
95-A2a								1	3	3			4	29100	94.4
90-A2a		1					4	7	6				7	31600	90.3
100-A2b													-	26600	100.0
95-A2b								1	3	2			4	29100	94.4
90-A2b		1					4	7	6				7	31600	90.3
100-A2c													-	26600	100.0
95-A2c								1	3	2			4	29100	94.4
90-A2c		1					4	7	6				7	31600	90.3
100-A3													-	31600	100.0
95-A3	3	3						1	3	4	1	2	4	37600	94.4
90-A3	4	4					4	4	6	1	3		7	40100	90.3
100-A4													-	26600	100.0
95-A4	1	1						2	3	4			4	29600	94.4
90-A4	3	3					3	6	6	1	1		7	32100	90.3

* Basin Yield = Reservoir Yield + Chain Lakes November-Through-April Yield

Table 4.2: Duration of Agricultural Demand Shortages

Scenario	Year of Occurrence	Duration, in months, starting in Month:						Reservoir Yield* (ac.-ft.)	Volume of Shortage (ac.-ft.)
		May	June	July	Aug.	Sept.	Oct.		
100-A1								6000	
95-A1	1931					2		9500	546
	1936				3				1862
	1944				3				2393
90-A1	1919				3			11000	1328
	1931				3				2842
	1936			4					5824
	1937				2				1003
	1944			4					4704
	1961				2				1599
	1983						1		362
100-A2a								23000	
95-A2a	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2a	1919				3			28000	5827
	1931				3				4612
	1936				3				11353
	1937					2			2203
	1944				3				7936
	1961					1			1478
	1983					2			3265
100-A2b								23000	
95-A2b	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2b	1919				3			28000	5827
	1931				3				4612
	1936				3				7798
	1937					2			824
	1944				3				7936
	1961					1			1478
	1983					2			3265

* Reservoir yield refers to that yield produced by the downstream reservoir during the May through October period. It does not include the contribution by Chain Lakes Reservoir.

...Table 4.2 continued...

...Table 4.2 concluded...

Scenario	Year of Occurrence	Duration, in months, starting in Month:						Reservoir Yield* (ac.-ft.)	Volume of Shortage (ac.-ft.)
		May	June	July	Aug.	Sept.	Oct.		
100-A2c								23000	
95-A2c	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2c	1919				3			28000	5827
	1931				3				4612
	1936				3				7798
	1937					2			824
	1944				3				7936
	1961					1			1478
	1973					2			3265
100-A3								28000	
95-A3	1919					2		34000	1528
	1936					2			4535
	1937				3				11889
	1944					1			282
90-A3	1919				3			36500	6200
	1931						1		1566
	1936				3				12353
	1937				3				13454
	1941				1				8701
	1944					2			4442
	1983						1		647
100-A4								23000	
95-A4	1919					2		26000	2500
	1931						1		248
	1937				3				3326
	1944				3				4048
90-A4	1919				3			28500	6596
	1931					2			2869
	1936					2			2567
	1937				3				5498
	1944				3				7068
	1961					1			1479
	1983						1		852

* Reservoir yield refers to that yield produced by the downstream reservoir during the May through October period. It does not include the contribution by Chain Lakes Reservoir.

Table 4.3: Duration of Winter Demand Shortages

Option	Year of Occurrence	Duration, in months, starting in Month:						Volume of Shortage* (ac.-ft.)
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
100-A1	1937				2			482
	1945				1			489
95-A1	1919		3					1649
	1931	5						2655
	1936				1			529
	1936	5						2995
	1937	4						1841
	1944	5						2762
	1978				1			405
90-A1	1919	4						2235
	1931	5						2655
	1935	4						2255
	1936	5						2995
	1937	4						1873
	1944	5						2762
	1951			2				855
	1963			3				1264
	1977		3					1495
	1983	2						1132
100-A2	NO WINTER DEMAND SHORTAGES							
95-A2	NO WINTER DEMAND SHORTAGES							
90-A2	1978				1			333
100-A3	NO WINTER DEMAND SHORTAGES							
95-A3	1936	4						1346
	1938			2				317
	1944		3					902
90-A3	1931		3					545
	1936	4						1346
	1938			2				317
	1944		3					902
100-A4	NO WINTER DEMAND SHORTAGES							
95-A4	1945			2				492
90-A4	1936	4						618
	1945			2				492
	1978			2				586

* Willow Creek Winter requirements (November through April) total 3,600 acre-feet.

5. CONCLUSIONS

The hydrologic assessment of the several alternatives was based on the effects of the proposed reservoirs on the Willow Creek Basin monthly streamflow data sets. Due to the daily variability of flows, conclusions extrapolated from these results for time periods of less than one month should be undertaken with caution.

The results of the analyses reveal the following conclusions.

1. The larger the reservoir storage available, the greater the maximum annual draft. Hence, alternative A3 provides the greatest annual draft, followed by A2, A4, and A1. However, the efficiency of attaining the greater annual draft does not parallel the above statement. The ratio of maximum annual draft and maximum live storage provide a measure of this efficiency. These ratios for the 90% level of reliability are presented in Table 5.1. As can be seen, Alternative A4 offers greatest efficiency, followed by A2, A1, and A3.

Table 5.1: Efficiency of Attaining Maximum Annual Draft

Alternative	Guaranteed Annual Draft	Maximum Live Storage	GAD/MLS
	at 90% Reliability		
	(GAD) (ac-ft)	(MLS) (ac-ft)	
A1	11000	11800	0.93
A2	28000 ✓	27490	1.02
A3	36500 ✓	45818	0.80
A4	28500 ✓	26731	1.07

2. Concerning Alternative A2, the reliability of the annual draft was shown to be very insensitive to the range of canal capacities tested in this assessment (as shown in Figure 3). Based on these results, it can be concluded that a canal capacity of 300 cfs would be adequate in supplying the Pine Coulee Offstream Reservoir. There is little or no gain in draft with a larger diversion canal capacity of 600 cfs or 900 cfs.
3. Under the proposed operation of reservoirs, Chain Lakes Reservoir would provide winter flows for municipal purposes only. The 10 cfs release requirement during the November through April period was always met by the existing reservoir. The 3 cfs requirement for Stimson Creek throughout the year was also always met.

However, in the options involving downstream reservoirs, there were, on occasion, downstream flows of less than 10 cfs during the November through April period. These shortages were caused by a combination of low reservoir levels and the formation of surface ice in the reservoir during the winter season.

Whether the alternative involved an onstream or offstream reservoir, flows of less than 10 cfs can still be expected downstream of the proposed reservoir due to the formation of channel ice.

4. The maximum reservoir draft shown in the storage-draft curves of Figures 8 through 11 were determined using a fixed distribution of demand, as presented in Table 3.2. Variation in the distribution of demands would have negligible effects on the computed yield. However, the effects of a significantly different distribution of demand on the resulting maximum reservoir draft should be verified using the procedures outlined in this report.

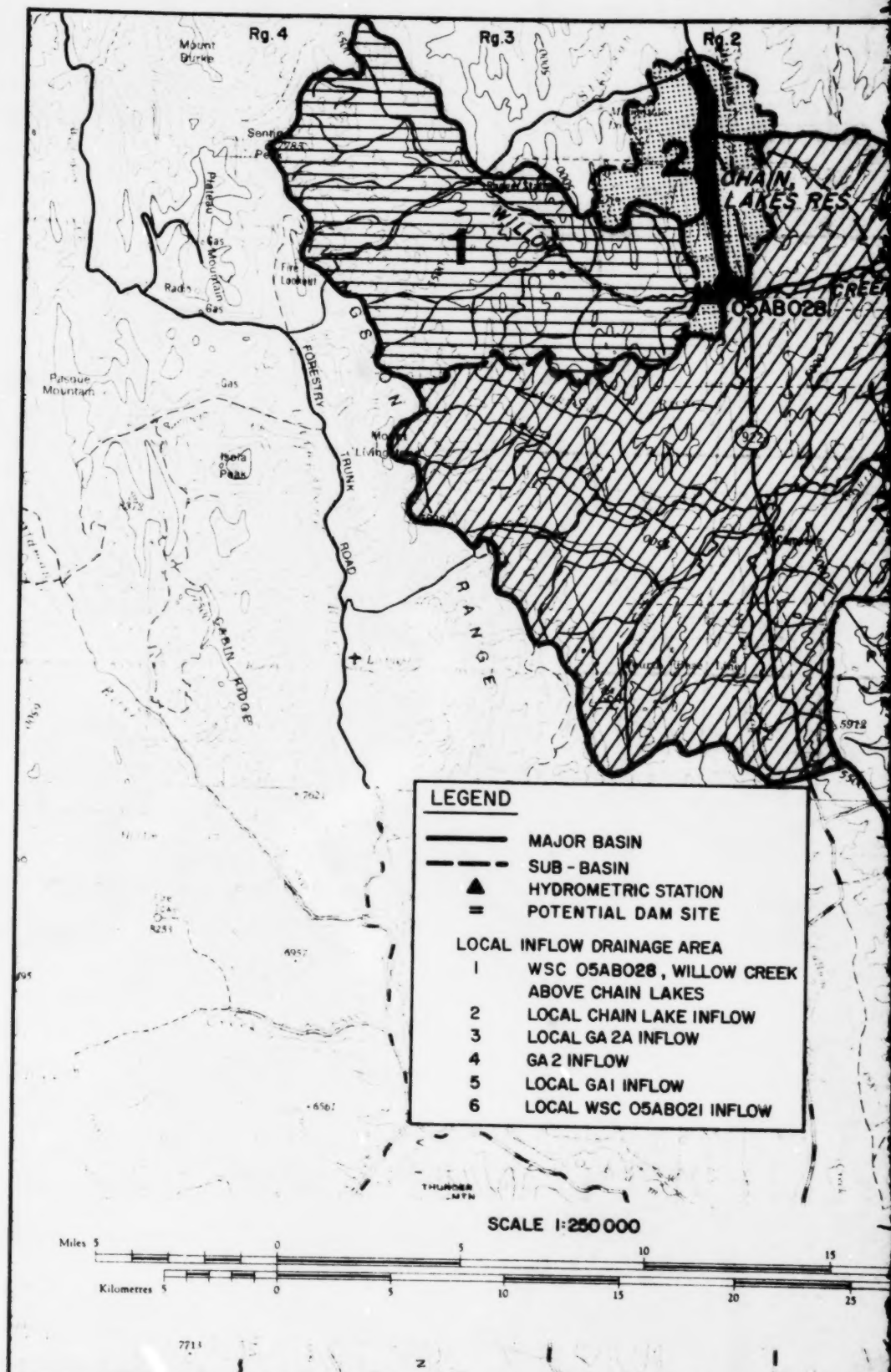
6. REFERENCES

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2. FIGLIUZZI, F. J. (1985). Natural Flows for Willow Creek Basin, Hydrology Branch, Alberta Environment, Edmonton, Alberta.
3. KLOHN LEONOFF (1984). Preliminary Planning Study Willow Creek Basin - Inventory of Storage Sites for Planning Division, Alberta Environment, Calgary, Alberta.
4. W.E.R. ENGINEERING LTD. (1981). South Saskatchewan River Basin Structures Inventory, Appendix 4, for Planning Division, Alberta Environment, Calgary, Alberta.

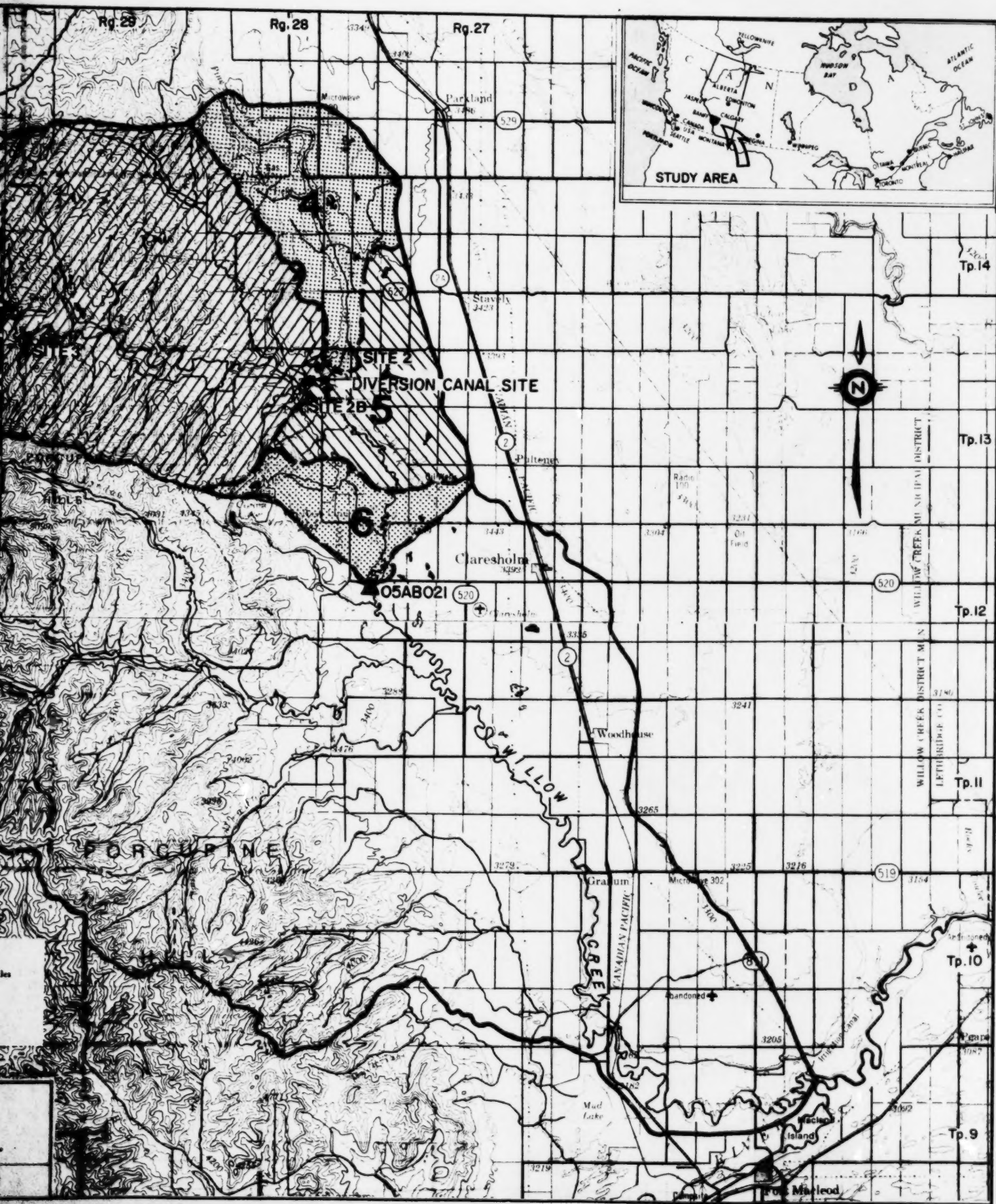
APPENDIX A

STREAMFLOW DATA SETS OF LOCAL DRAINAGE AREAS

Local Inflow Drainage Basins	Figure A1
WSC Station 05AB028: Willow Creek Above Chain Lakes ..	Table A1
Chain Lakes Local Inflow	Table A2
Local Inflow to Site #2A	Table A3
Local Inflow to Pine Coulee Reservoir (Site #2)	Table A4
Local Inflow to Claresholm Reservoir (Site #1)	Table A5
Local Inflow to Pine and Willow Reservoir (Site #2B) ..	Table A6
Local Inflow to WSC Station 05AB021	Table A7
WSC Station 05AB021: Willow Creek near Claresholm	Table A8



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	WILLOW CREEK LOCAL INFLOW DRAINAGE	
SUBMITTED DATE	DESIGNED P. STEVENS P. ENG. CHECKED	SCALE 1:250 000 DATE SEPT. 1998	
APPROVED DATE	DRAWN S.B.N. CHECKED		



WSC STATION 05AB028, WILLOW CREEK NEAR CLARESHOLM (CFS)

1912	6	10	90	177	261	299	344	227	96	77	41	25
1913	7	15	30	310	334	253	213	145	66	58	34	19
1914	7	13	29	140	140	129	68	21	17	80	42	25
1915	7	15	41	103	784	1103	829	454	195	113	54	50
1916	7	33	102	168	274	876	408	134	159	142	68	51
1917	9	16	43	301	1050	1261	276	122	71	56	42	14
1918	8	17	54	81	135	100	23	15	27	27	13	4
1919	6	6	5	90	120	45	3	6	6	15	22	8
1920	7	9	66	222	945	427	146	32	17	21	17	7
1921	4	11	37	133	144	96	28	7	8	17	11	6
1922	3	1	4	171	322	140	62	15	6	11	9	2
1923	4	1	10	77	118	1491	455	217	78	49	30	17
1924	7	12	47	179	255	434	146	128	35	30	21	11
1925	6	9	63	246	195	310	55	25	35	104	51	54
1926	8	17	26	122	79	332	226	64	349	191	77	54
1927	9	23	70	152	888	1119	301	259	451	296	105	80
1928	10	29	242	319	363	673	726	262	114	82	43	26
1929	7	15	57	189	569	864	120	41	32	36	24	13
1930	6	74	63	220	232	201	73	16	20	25	19	9
1931	6	8	27	60	75	67	15	7	13	12	11	5
1932	5	6	24	85	246	954	50	27	27	26	19	9
1933	6	8	24	226	323	258	65	26	25	17	14	7
1934	6	7	46	148	271	117	30	6	13	18	15	7
1935	6	7	18	249	121	104	38	7	2	11	10	4
1936	5	6	88	209	51	45	3	1	1	1	2	1
1937	3	2	7	70	75	250	36	14	8	23	18	8
1938	6	8	39	173	440	209	107	22	7	15	13	6
1939	5	7	65	64	49	426	92	13	9	29	21	11
1940	6	9	32	122	192	84	31	10	46	45	29	16
1941	7	11	23	44	50	95	25	10	42	42	27	14
1942	7	11	23	121	1085	1109	496	264	163	114	54	35
1943	8	18	123	363	241	210	72	16	10	18	15	7
1944	2	2	9	81	46	52	25	8	5	9	8	3
1945	1	1	20	37	284	522	151	27	33	41	21	31
1946	13	15	51	72	115	348	79	27	66	54	32	21
1947	17	46	125	312	358	330	94	74	149	116	71	54
1948	37	29	138	481	1276	885	299	135	57	44	28	9
1949	5	4	19	131	132	120	36	4	5	14	19	8
1950	2	14	41	121	190	136	35	19	5	13	8	8
1951	6	5	277	224	561	1115	471	223	463	307	134	82
1952	19	60	166	491	310	324	190	127	63	42	29	17
1953	11	20	115	235	744	2193	396	119	67	45	39	26
1954	23	36	27	186	482	323	84	82	95	127	72	34
1955	13	21	24	400	840	466	399	77	46	43	18	23
1956	19	12	97	140	250	110	199	40	30	24	25	13
1957	5	17	56	185	309	207	42	22	20	35	31	17
1958	11	12	53	372	397	263	357	111	46	26	24	22
1959	14	10	146	173	339	262	75	34	38	34	39	28
1960	21	36	203	104	304	139	26	19	6	10	9	8
1961	9	10	21	44	171	67	15	16	11	46	30	15
1962	31	50	160	338	137	91	26	9	11	11	10	7
1963	6	14	15	28	68	497	508	45	24	18	13	11
1964	5	5	5	80	488	296	86	22	33	24	18	8
1965	5	52	16	241	133	346	266	63	95	64	33	25
1966	11	12	98	100	189	433	99	58	24	29	24	11
1967	5	9	124	116	842	1079	179	51	15	16	18	7
1968	10	10	41	38	85	163	66	48	99	150	59	35
1969	24	20	125	535	424	685	871	92	42	41	37	15
1970	21	28	56	122	310	396	110	21	18	29	7	10
1971	55	113	81	209	160	242	40	4	11	22	14	2
1972	3	11	235	325	601	284	81	130	81	70	58	28
1973	41	48	75	176	409	257	59	29	25	24	16	17
1974	13	19	111	213	776	430	84	61	46	40	26	23
1975	16	26	52	283	629	589	249	90	41	38	21	18
1976	37	14	116	138	179	97	28	312	47	30	16	20
1977	24	8	27	73	41	17	2	16	15	17	2	5
1978	3	0	126	127	454	361	198	78	68	36	32	17
1979	5	17	97	229	501	182	40	37	20	17	5	8
1980	4	12	27	135	132	195	20	24	30	30	21	25
1981	16	23	35	35	689	511	175	86	22	22	14	0
1982	0	0	11	112	67	202	72	10	16	18	15	12
1983	17	17	41	69	97	69	25	0	0	7	17	12

LOCAL INFLOW TO WSC STATION 05AB021 (CFS)

1912	0.	1.	3.	3.	4.	4.	7.	9.	1.	3.	2.	1.
1913	0.	1.	0.	7.	5.	3.	3.	5.	0.	1.	1.	1.
1914	0.	1.	0.	2.	2.	1.	0.	-1.	0.	4.	2.	1.
1915	0.	1.	1.	1.	14.	26.	26.	24.	2.	5.	3.	4.
1916	0.	3.	3.	3.	4.	19.	9.	4.	1.	4.	3.	3.
1917	0.	1.	1.	7.	19.	31.	5.	3.	0.	4.	3.	1.
1918	0.	1.	1.	1.	2.	0.	0.	-1.	0.	0.	0.	-1.
1919	0.	0.	0.	1.	1.	0.	0.	-1.	0.	0.	1.	0.
1920	0.	1.	2.	4.	17.	7.	2.	0.	0.	1.	1.	0.
1921	0.	1.	0.	2.	2.	0.	0.	-1.	0.	0.	0.	0.
1922	0.	0.	0.	3.	5.	1.	0.	-1.	0.	0.	0.	0.
1923	0.	0.	0.	1.	1.	38.	11.	9.	1.	3.	2.	1.
1924	0.	1.	1.	3.	4.	7.	2.	4.	0.	1.	1.	0.
1925	0.	0.	1.	5.	3.	4.	0.	0.	0.	3.	2.	4.
1926	0.	1.	0.	2.	1.	5.	4.	1.	4.	1.	2.	3.
1927	-1.	1.	2.	3.	16.	26.	6.	11.	5.	-3.	2.	4.
1928	-2.	2.	11.	7.	6.	13.	21.	11.	1.	4.	2.	1.
1929	0.	1.	1.	4.	9.	19.	1.	0.	0.	2.	1.	1.
1930	0.	7.	1.	4.	3.	2.	0.	-1.	0.	1.	1.	0.
1931	0.	0.	0.	1.	1.	0.	0.	-1.	0.	1.	1.	0.
1932	0.	0.	0.	1.	4.	21.	0.	0.	0.	1.	1.	0.
1933	0.	0.	0.	5.	5.	3.	0.	0.	0.	1.	1.	0.
1934	0.	0.	1.	2.	4.	1.	0.	-1.	0.	1.	1.	0.
1935	0.	0.	0.	5.	2.	1.	0.	-1.	0.	0.	0.	0.
1936	0.	0.	3.	4.	1.	0.	0.	0.	0.	0.	0.	0.
1937	0.	0.	0.	1.	1.	3.	0.	-1.	0.	0.	0.	0.
1938	0.	0.	1.	3.	7.	2.	1.	-1.	0.	0.	0.	0.
1939	0.	0.	2.	1.	1.	7.	0.	-1.	0.	0.	1.	0.
1940	0.	0.	0.	2.	3.	0.	0.	-1.	0.	-2.	0.	0.
1941	0.	0.	0.	0.	1.	0.	0.	-1.	0.	-3.	0.	0.
1942	0.	0.	0.	2.	20.	26.	13.	11.	1.	5.	3.	2.
1943	0.	1.	4.	9.	3.	2.	0.	-1.	0.	1.	1.	0.
1944	0.	0.	0.	1.	0.	0.	0.	-1.	0.	0.	0.	0.
1945	0.	0.	0.	0.	4.	9.	3.	0.	0.	-1.	0.	2.
1946	1.	1.	1.	1.	1.	5.	1.	0.	0.	1.	1.	1.
1947	1.	4.	4.	7.	5.	5.	1.	3.	1.	3.	4.	4.
1948	3.	2.	5.	13.	24.	19.	3.	2.	0.	3.	2.	0.
1949	0.	0.	0.	2.	2.	1.	0.	-1.	0.	0.	1.	0.
1950	0.	1.	1.	2.	3.	1.	-1.	0.	0.	0.	0.	0.
1951	0.	0.	13.	5.	9.	26.	11.	9.	6.	1.	5.	4.
1952	-1.	5.	7.	13.	5.	5.	3.	4.	0.	2.	2.	1.
1953	1.	2.	4.	5.	13.	62.	7.	1.	0.	3.	3.	2.
1954	2.	3.	0.	3.	8.	5.	-1.	1.	1.	5.	4.	2.
1955	0.	1.	0.	10.	15.	8.	11.	1.	0.	2.	0.	1.
1956	1.	1.	3.	2.	4.	1.	4.	0.	0.	1.	1.	1.
1957	0.	1.	1.	3.	5.	2.	-2.	0.	0.	2.	2.	1.
1958	1.	1.	1.	9.	6.	3.	10.	2.	0.	1.	1.	2.
1959	1.	1.	6.	3.	5.	3.	-2.	0.	0.	1.	2.	2.
1960	2.	3.	9.	1.	5.	1.	-1.	0.	0.	0.	0.	0.
1961	1.	1.	0.	0.	2.	0.	0.	-1.	0.	-4.	0.	0.
1962	2.	4.	6.	8.	2.	0.	0.	0.	0.	0.	0.	0.
1963	0.	1.	0.	0.	1.	9.	14.	0.	0.	1.	1.	1.
1964	0.	0.	0.	1.	8.	4.	1.	0.	0.	0.	1.	0.
1965	0.	5.	0.	5.	2.	5.	6.	0.	1.	0.	1.	1.
1966	0.	1.	3.	1.	3.	7.	0.	-1.	0.	1.	1.	1.
1967	0.	1.	4.	2.	15.	25.	-3.	0.	0.	0.	1.	0.
1968	1.	1.	1.	0.	1.	1.	0.	1.	1.	10.	4.	2.
1969	2.	1.	4.	15.	7.	14.	31.	2.	0.	2.	3.	1.
1970	2.	2.	1.	2.	5.	6.	1.	-1.	0.	2.	0.	0.
1971	5.	11.	2.	4.	2.	3.	0.	-1.	0.	1.	1.	0.
1972	0.	1.	11.	8.	10.	4.	-1.	5.	1.	4.	4.	2.
1973	4.	4.	2.	3.	6.	3.	0.	0.	0.	1.	1.	1.
1974	1.	2.	4.	4.	13.	7.	0.	1.	0.	1.	1.	1.
1975	1.	2.	1.	6.	11.	11.	4.	1.	0.	2.	1.	1.
1976	3.	1.	4.	2.	2.	0.	0.	15.	0.	1.	0.	1.
1977	2.	0.	0.	1.	0.	0.	0.	0.	0.	0.	-1.	0.
1978	0.	0.	4.	2.	13.	6.	5.	2.	2.	1.	2.	1.
1979	0.	1.	4.	6.	11.	3.	0.	0.	1.	1.	0.	0.
1980	0.	1.	1.	2.	0.	1.	0.	0.	0.	0.	0.	2.
1981	1.	2.	0.	0.	3.	10.	4.	2.	0.	0.	0.	-1.
1982	-1.	-1.	0.	1.	1.	1.	1.	0.	0.	0.	0.	1.
1983	1.	1.	0.	1.	1.	0.	-1.	-1.	0.	0.	1.	1.

LOCAL INFLOW TO PINE + WILLOW RESERVOIR (SITE #2B) (CFS)

1912	3.	5.	65.	117.	148.	160.	196.	106.	62.	33.	17.	11.
1913	2.	7.	24.	198.	157.	127.	139.	48.	42.	27.	13.	8.
1914	1.	6.	24.	95.	66.	63.	49.	17.	13.	36.	19.	11.
1915	2.	7.	34.	75.	400.	621.	516.	201.	145.	47.	22.	23.
1916	1.	15.	82.	104.	154.	418.	234.	-52.	70.	46.	23.	21.
1917	1.	6.	36.	213.	640.	668.	191.	88.	51.	29.	21.	7.
1918	5.	9.	46.	56.	58.	55.	16.	0.	21.	14.	6.	1.
1919	2.	2.	5.	63.	43.	33.	1.	-8.	3.	10.	12.	4.
1920	4.	5.	55.	143.	552.	235.	59.	16.	11.	12.	9.	4.
1921	2.	6.	31.	89.	63.	43.	14.	3.	4.	11.	6.	3.
1922	1.	0.	4.	123.	172.	69.	41.	12.	3.	7.	5.	1.
1923	2.	0.	9.	51.	62.	848.	332.	141.	55.	25.	14.	9.
1924	3.	6.	39.	116.	137.	247.	100.	30.	24.	17.	11.	6.
1925	3.	5.	46.	140.	83.	171.	35.	15.	24.	39.	19.	24.
1926	2.	8.	19.	69.	42.	204.	168.	50.	261.	33.	17.	16.
1927	-2.	8.	54.	99.	521.	635.	190.	10.	341.	-13.	10.	21.
1928	-7.	9.	154.	212.	177.	376.	492.	172.	82.	36.	18.	11.
1929	2.	7.	42.	129.	308.	459.	90.	35.	22.	19.	12.	7.
1930	2.	38.	50.	129.	107.	96.	42.	10.	13.	14.	9.	5.
1931	3.	3.	20.	39.	38.	34.	10.	7.	8.	8.	6.	3.
1932	3.	3.	20.	58.	123.	511.	31.	19.	17.	14.	9.	4.
1933	3.	3.	20.	145.	161.	137.	40.	18.	16.	10.	7.	3.
1934	3.	3.	37.	97.	135.	61.	18.	6.	8.	10.	8.	3.
1935	3.	4.	16.	181.	62.	51.	19.	2.	1.	8.	6.	2.
1936	3.	3.	73.	149.	21.	20.	1.	0.	0.	1.	1.	0.
1937	1.	1.	8.	52.	39.	142.	23.	12.	4.	13.	9.	3.
1938	3.	4.	33.	124.	198.	97.	63.	18.	5.	10.	7.	3.
1939	3.	4.	54.	45.	14.	240.	63.	9.	6.	16.	11.	6.
1940	2.	4.	28.	80.	97.	40.	19.	8.	36.	20.	12.	7.
1941	1.	5.	18.	30.	20.	45.	17.	5.	24.	19.	10.	5.
1942	1.	5.	19.	82.	680.	531.	298.	96.	58.	44.	20.	14.
1943	2.	8.	92.	223.	124.	111.	49.	10.	7.	11.	8.	4.
1944	1.	1.	8.	61.	15.	30.	16.	7.	3.	7.	6.	2.
1945	1.	0.	18.	26.	137.	282.	91.	12.	22.	22.	9.	15.
1946	6.	7.	38.	46.	54.	165.	41.	10.	44.	23.	12.	9.
1947	8.	22.	81.	205.	191.	146.	58.	44.	95.	42.	28.	23.
1948	16.	13.	111.	330.	753.	491.	213.	84.	45.	22.	14.	4.
1949	2.	2.	16.	84.	57.	59.	26.	4.	3.	9.	10.	4.
1950	1.	6.	35.	77.	93.	78.	26.	9.	3.	9.	4.	4.
1951	3.	3.	197.	152.	306.	599.	279.	60.	243.	21.	29.	24.
1952	-2.	25.	117.	323.	179.	155.	117.	77.	44.	22.	15.	8.
1953	5.	10.	88.	147.	433.	1193.	270.	88.	56.	23.	19.	13.
1954	11.	18.	19.	124.	258.	178.	57.	41.	61.	52.	30.	14.
1955	5.	10.	17.	274.	503.	263.	247.	57.	39.	22.	8.	11.
1956	9.	6.	75.	100.	117.	65.	124.	24.	15.	14.	13.	6.
1957	2.	8.	44.	114.	163.	104.	34.	17.	16.	19.	16.	9.
1958	5.	6.	44.	261.	211.	135.	201.	75.	34.	15.	12.	12.
1959	6.	5.	104.	120.	183.	125.	56.	27.	32.	18.	19.	14.
1960	10.	18.	145.	76.	161.	77.	22.	12.	4.	6.	5.	4.
1961	4.	5.	14.	29.	74.	44.	10.	8.	8.	22.	12.	6.
1962	14.	24.	119.	238.	62.	48.	18.	7.	8.	7.	5.	3.
1963	3.	7.	13.	18.	24.	287.	318.	38.	17.	10.	7.	6.
1964	2.	2.	4.	55.	248.	166.	58.	16.	27.	14.	9.	4.
1965	2.	26.	9.	153.	59.	172.	174.	48.	57.	39.	19.	14.
1966	8.	7.	71.	66.	98.	265.	56.	32.	12.	14.	9.	5.
1967	2.	4.	101.	76.	507.	601.	166.	45.	14.	13.	11.	3.
1968	3.	5.	31.	23.	36.	69.	38.	25.	53.	54.	20.	8.
1969	7.	6.	107.	356.	243.	325.	477.	71.	35.	24.	19.	8.
1970	14.	15.	47.	93.	154.	173.	62.	18.	13.	16.	3.	5.
1971	27.	55.	65.	148.	57.	117.	26.	5.	7.	11.	5.	2.
1972	1.	5.	169.	215.	357.	174.	55.	56.	42.	20.	20.	10.
1973	16.	19.	48.	105.	218.	153.	44.	20.	16.	14.	9.	9.
1974	7.	10.	86.	127.	455.	247.	62.	40.	29.	19.	13.	9.
1975	9.	13.	42.	216.	341.	317.	145.	60.	30.	20.	13.	10.
1976	17.	7.	89.	88.	85.	48.	10.	83.	26.	16.	8.	8.
1977	11.	2.	20.	54.	22.	10.	0.	8.	5.	7.	1.	2.
1978	1.	-1.	123.	73.	235.	210.	108.	43.	42.	18.	12.	6.
1979	0.	7.	64.	154.	292.	115.	28.	26.	13.	10.	3.	1.
1980	0.	6.	23.	77.	64.	93.	9.	11.	13.	16.	5.	9.
1981	3.	7.	21.	17.	340.	295.	105.	52.	15.	15.	9.	2.
1982	2.	2.	13.	87.	29.	99.	45.	9.	14.	12.	9.	7.
1983	9.	8.	32.	30.	30.	24.	14.	-2.	-1.	5.	10.	8.

LOCAL INFLOW TO CLARESHOLM RESERVOIR (SITE #1) (CFS)

1912	0.	1.	8.	7.	10.	12.	24.	34.	0.	11.	6.	4.
1913	-1.	2.	1.	20.	16.	7.	11.	16.	2.	2.	4.	1.
1914	0.	1.	0.	5.	5.	3.	0.	-1.	0.	13.	7.	4.
1915	-1.	2.	0.	1.	43.	83.	83.	81.	2.	14.	7.	11.
1916	-2.	9.	0.	7.	10.	59.	30.	12.	1.	12.	10.	10.
1917	-3.	1.	1.	22.	48.	81.	10.	9.	-1.	12.	10.	1.
1918	0.	4.	3.	1.	6.	2.	-2.	-2.	0.	0.	-1.	-1.
1919	0.	0.	-2.	2.	6.	-1.	-1.	-1.	0.	0.	5.	1.
1920	1.	1.	3.	12.	50.	22.	4.	-2.	0.	3.	3.	0.
1921	0.	2.	1.	6.	6.	1.	-2.	-1.	0.	1.	1.	0.
1922	0.	-1.	-2.	8.	14.	3.	-1.	-2.	0.	1.	1.	-1.
1923	0.	-1.	-2.	0.	1.	80.	32.	30.	0.	10.	6.	2.
1924	1.	2.	2.	9.	12.	23.	3.	12.	-1.	1.	2.	0.
1925	0.	1.	4.	15.	8.	13.	-2.	-3.	-1.	10.	6.	13.
1926	-2.	2.	0.	5.	3.	14.	10.	2.	13.	2.	6.	8.
1927	-4.	4.	4.	6.	47.	84.	19.	40.	19.	-17.	3.	12.
1928	-7.	4.	35.	22.	16.	42.	76.	41.	2.	14.	8.	5.
1929	-1.	2.	4.	9.	28.	59.	2.	-1.	-1.	7.	5.	1.
1930	1.	26.	4.	12.	11.	6.	-1.	-2.	0.	4.	4.	1.
1931	1.	2.	0.	0.	3.	0.	-2.	-1.	0.	1.	2.	0.
1932	1.	1.	0.	2.	11.	69.	-2.	-3.	0.	3.	3.	1.
1933	0.	2.	0.	12.	14.	9.	-1.	-3.	0.	2.	2.	1.
1934	1.	2.	1.	7.	12.	1.	-2.	-1.	0.	2.	2.	1.
1935	1.	1.	0.	15.	4.	0.	-2.	-1.	0.	-2.	0.	-1.
1936	0.	1.	7.	11.	1.	-1.	-1.	0.	0.	0.	0.	0.
1937	1.	0.	-1.	1.	3.	9.	-1.	-2.	0.	-1.	2.	0.
1938	0.	1.	0.	8.	22.	7.	0.	-1.	0.	0.	2.	0.
1939	0.	1.	3.	0.	1.	22.	1.	-2.	0.	0.	1.	0.
1940	0.	1.	0.	5.	8.	1.	-2.	-1.	0.	-9.	-1.	-1.
1941	-1.	1.	0.	1.	1.	0.	-2.	-1.	0.	-13.	-2.	-2.
1942	-1.	0.	0.	4.	59.	83.	43.	42.	5.	15.	8.	6.
1943	-2.	3.	13.	25.	12.	7.	-1.	-2.	0.	1.	2.	0.
1944	-1.	-1.	-1.	2.	2.	0.	1.	-2.	0.	0.	0.	-1.
1945	-1.	-1.	0.	0.	14.	30.	10.	1.	0.	-1.	0.	7.
1946	1.	3.	2.	1.	5.	16.	4.	1.	1.	0.	3.	2.
1947	2.	15.	13.	22.	16.	14.	0.	8.	4.	12.	13.	13.
1948	9.	7.	15.	37.	65.	59.	4.	4.	0.	9.	5.	0.
1949	0.	-1.	0.	4.	5.	1.	-1.	-2.	0.	-1.	3.	1.
1950	-1.	4.	0.	4.	7.	2.	-5.	-1.	0.	0.	0.	1.
1951	1.	0.	42.	12.	29.	85.	36.	30.	19.	-1.	18.	14.
1952	-2.	17.	20.	38.	13.	13.	7.	12.	0.	8.	5.	3.
1953	2.	5.	11.	14.	38.	201.	20.	1.	1.	9.	10.	6.
1954	7.	12.	0.	9.	25.	12.	-2.	1.	1.	19.	15.	5.
1955	0.	4.	0.	30.	42.	24.	38.	3.	0.	5.	1.	5.
1956	5.	1.	9.	7.	11.	0.	14.	-1.	-1.	2.	6.	2.
1957	0.	5.	3.	10.	13.	6.	-6.	-1.	0.	6.	7.	3.
1958	2.	2.	3.	26.	19.	11.	32.	5.	0.	2.	5.	4.
1959	4.	1.	16.	9.	15.	9.	-7.	-2.	-1.	1.	9.	6.
1960	5.	11.	26.	4.	13.	2.	-3.	-1.	0.	1.	1.	2.
1961	2.	2.	0.	1.	8.	0.	0.	-2.	0.	-14.	-2.	-2.
1962	8.	16.	20.	24.	5.	0.	0.	-1.	0.	0.	1.	1.
1963	1.	4.	-1.	0.	2.	28.	48.	-1.	0.	4.	2.	2.
1964	1.	1.	-1.	2.	24.	12.	4.	-1.	0.	2.	2.	0.
1965	0.	18.	-1.	14.	5.	15.	17.	-2.	1.	-1.	1.	3.
1966	-1.	0.	9.	4.	8.	23.	-4.	-2.	0.	5.	6.	1.
1967	0.	1.	12.	2.	20.	67.	-17.	-2.	-1.	0.	2.	-1.
1968	1.	1.	0.	-2.	2.	4.	0.	1.	2.	39.	14.	9.
1969	6.	5.	1.	42.	19.	45.	112.	5.	0.	8.	9.	2.
1970	5.	9.	3.	5.	15.	23.	5.	-2.	0.	5.	-1.	2.
1971	20.	42.	8.	12.	7.	9.	0.	-3.	0.	3.	1.	-2.
1972	0.	2.	31.	21.	29.	8.	-7.	16.	1.	16.	16.	6.
1973	12.	16.	6.	11.	23.	10.	-1.	0.	0.	3.	2.	4.
1974	3.	5.	12.	13.	47.	22.	1.	0.	1.	5.	4.	6.
1975	4.	8.	4.	18.	31.	33.	11.	4.	0.	6.	2.	3.
1976	13.	3.	11.	7.	9.	1.	1.	55.	0.	1.	1.	5.
1977	7.	1.	0.	1.	2.	-1.	-1.	0.	-1.	0.	-3.	-1.
1978	-1.	-2.	-16.	2.	46.	19.	15.	6.	4.	4.	7.	3.
1979	0.	5.	10.	17.	35.	12.	0.	1.	1.	2.	-1.	1.
1980	0.	3.	0.	9.	-1.	2.	0.	0.	-2.	-2.	2.	5.
1981	3.	7.	1.	1.	5.	33.	13.	7.	0.	0.	0.	-3.
1982	-1.	-1.	-2.	1.	5.	3.	3.	-2.	-2.	-1.	1.	1.
1983	5.	5.	0.	2.	1.	0.	-3.	-2.	0.	-2.	3.	2.

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1912	1.	1.	2.	6.	4.	4.	5.	2.	2.	1.	1.	1.
1913	1.	1.	0.	7.	3.	5.	2.	1.	0.	1.	1.	1.
1914	0.	1.	0.	4.	1.	0.	0.	0.	0.	2.	2.	1.
1915	1.	1.	1.	4.	9.	17.	16.	10.	5.	4.	3.	2.
1916	1.	1.	13.	4.	5.	14.	7.	4.	4.	4.	2.	2.
1917	1.	1.	1.	4.	26.	37.	10.	5.	3.	2.	2.	1.
1918	1.	1.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.
1919	0.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.
1920	0.	0.	2.	5.	15.	5.	2.	1.	0.	0.	0.	0.
1921	0.	0.	1.	2.	1.	1.	0.	0.	0.	0.	0.	0.
1922	0.	0.	1.	4.	4.	1.	1.	0.	0.	0.	0.	0.
1923	0.	0.	1.	3.	5.	67.	11.	3.	1.	1.	1.	1.
1924	0.	1.	1.	4.	2.	5.	2.	2.	1.	1.	1.	1.
1925	0.	1.	2.	5.	2.	4.	1.	1.	1.	2.	2.	1.
1926	1.	1.	0.	2.	0.	4.	4.	1.	2.	3.	2.	1.
1927	1.	1.	2.	3.	14.	18.	4.	3.	2.	4.	3.	2.
1928	1.	1.	8.	7.	5.	9.	8.	3.	1.	1.	1.	1.
1929	1.	1.	1.	4.	8.	13.	2.	1.	1.	1.	1.	1.
1930	0.	1.	2.	5.	2.	2.	1.	0.	0.	0.	0.	0.
1931	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
1932	0.	0.	0.	1.	2.	14.	1.	1.	0.	0.	0.	0.
1933	0.	0.	0.	5.	4.	3.	1.	1.	0.	0.	0.	0.
1934	0.	0.	1.	3.	3.	1.	0.	0.	0.	0.	0.	0.
1935	0.	0.	0.	5.	1.	1.	1.	0.	0.	0.	0.	0.
1936	0.	0.	2.	5.	0.	0.	0.	0.	0.	0.	0.	0.
1937	0.	0.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.
1938	0.	0.	1.	4.	5.	2.	2.	0.	0.	0.	0.	0.
1939	0.	0.	2.	1.	0.	5.	1.	0.	0.	1.	1.	1.
1940	0.	1.	1.	2.	2.	0.	0.	0.	1.	1.	1.	1.
1941	0.	1.	0.	0.	0.	1.	0.	0.	1.	1.	1.	1.
1942	0.	1.	0.	2.	18.	17.	6.	3.	1.	2.	2.	1.
1943	1.	1.	4.	8.	2.	2.	1.	0.	0.	0.	0.	0.
1944	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
1945	0.	0.	0.	0.	2.	6.	2.	0.	0.	0.	0.	0.
1946	0.	0.	1.	1.	1.	4.	1.	0.	1.	1.	1.	1.
1947	1.	1.	4.	6.	5.	4.	1.	1.	1.	2.	2.	1.
1948	1.	1.	5.	12.	27.	16.	5.	2.	1.	1.	1.	1.
1949	0.	1.	0.	4.	1.	1.	0.	0.	0.	0.	0.	0.
1950	0.	0.	1.	2.	2.	1.	1.	0.	0.	0.	0.	0.
1951	0.	0.	9.	5.	7.	16.	6.	3.	2.	4.	2.	2.
1952	1.	1.	5.	12.	4.	4.	3.	2.	1.	1.	1.	1.
1953	0.	1.	4.	4.	12.	37.	5.	2.	1.	1.	1.	1.
1954	0.	1.	0.	5.	5.	5.	1.	1.	1.	2.	2.	1.
1955	1.	1.	0.	8.	15.	7.	5.	1.	1.	1.	1.	1.
1956	0.	1.	3.	2.	2.	1.	3.	1.	1.	0.	0.	0.
1957	0.	0.	1.	4.	4.	2.	1.	0.	0.	1.	1.	1.
1958	0.	1.	1.	9.	5.	2.	5.	2.	1.	1.	1.	1.
1959	0.	1.	5.	3.	5.	4.	1.	1.	1.	1.	1.	1.
1960	0.	1.	7.	2.	4.	2.	0.	0.	0.	0.	0.	0.
1961	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.	1.	1.
1962	0.	1.	5.	7.	1.	1.	0.	0.	0.	0.	0.	0.
1963	0.	0.	0.	0.	0.	5.	6.	1.	0.	0.	0.	0.
1964	0.	0.	0.	1.	6.	3.	1.	0.	0.	0.	0.	0.
1965	0.	0.	0.	5.	1.	4.	4.	1.	1.	1.	1.	1.
1966	1.	1.	3.	1.	1.	5.	2.	1.	0.	0.	0.	0.
1967	0.	0.	5.	4.	37.	30.	4.	2.	1.	1.	1.	1.
1968	1.	1.	1.	2.	1.	2.	0.	0.	0.	0.	0.	0.
1969	0.	1.	16.	14.	6.	7.	8.	2.	1.	1.	1.	1.
1970	1.	1.	1.	2.	2.	1.	0.	0.	0.	0.	0.	0.
1971	0.	0.	1.	4.	1.	2.	0.	0.	0.	0.	0.	0.
1972	0.	0.	10.	8.	10.	6.	2.	1.	0.	1.	1.	1.
1973	1.	1.	1.	1.	2.	2.	0.	0.	0.	0.	0.	0.
1974	0.	0.	2.	4.	5.	5.	1.	2.	0.	0.	0.	0.
1975	0.	0.	0.	6.	9.	10.	6.	2.	1.	1.	1.	1.
1976	0.	1.	4.	2.	1.	1.	0.	3.	1.	0.	0.	0.
1977	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
1978	0.	0.	30.	4.	4.	3.	2.	0.	2.	0.	0.	0.
1979	0.	0.	3.	4.	5.	1.	0.	0.	0.	0.	0.	0.
1980	0.	0.	2.	1.	1.	0.	0.	0.	0.	0.	0.	0.
1981	0.	0.	0.	0.	8.	3.	1.	0.	0.	0.	0.	0.
1982	0.	0.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.
1983	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

WSC STATION 05AB028: WILLOW CREEK ABOVE CHAIN LAKES

1912	3	3	12	45	92	115	108	74	30	29	15	9
1913	6	5	4	78	147	109	54	73	20	27	15	9
1914	6	5	4	34	63	58	17	5	4	26	14	9
1915	6	5	5	23	307	346	186	141	40	45	21	12
1916	8	6	15	49	99	358	125	167	82	77	31	17
1917	11	8	4	52	316	451	63	19	19	11	8	5
1918	3	3	3	21	65	40	8	18	5	12	8	5
1919	4	4	2	22	67	12	3	16	3	5	4	3
1920	2	2	5	57	302	151	77	17	6	5	4	3
1921	2	2	4	32	69	49	15	6	4	5	4	3
1922	2	2	2	32	122	63	20	6	3	3	3	2
1923	2	2	3	23	51	490	69	33	20	11	8	5
1924	3	3	4	46	95	145	37	79	11	10	7	5
1925	3	3	11	80	95	114	20	12	11	50	23	13
1926	8	6	6	43	31	100	38	9	61	149	50	26
1927	16	10	8	40	281	347	78	193	74	318	87	42
1928	25	14	38	70	154	225	121	33	26	27	15	9
1929	6	5	9	42	209	306	23	6	10	8	6	4
1930	3	3	7	69	105	91	30	8	7	6	5	3
1931	2	3	6	18	31	31	7	2	5	2	2	2
1932	1	2	3	22	102	330	19	10	9	8	6	4
1933	3	3	3	58	134	102	24	10	8	4	4	3
1934	2	2	6	38	113	50	13	2	5	5	4	3
1935	2	2	2	42	50	49	20	7	1	5	4	3
1936	2	2	3	39	27	25	3	1	1	0	1	1
1937	1	1	0	14	30	89	13	5	4	10	7	5
1938	3	3	4	33	201	97	40	5	2	5	4	3
1939	2	2	5	16	32	146	25	7	3	12	8	5
1940	4	4	3	32	79	40	13	4	9	34	17	10
1941	7	5	4	12	27	47	9	7	17	37	18	11
1942	7	6	3	30	298	442	130	110	94	48	22	13
1943	8	6	12	97	96	84	22	8	3	5	4	3
1944	2	2	2	15	28	20	7	4	2	2	2	2
1945	1	2	2	10	121	188	43	13	10	20	12	7
1946	5	4	9	22	52	153	31	15	19	29	15	9
1947	6	5	24	70	136	156	32	18	45	56	25	14
1948	9	7	4	90	401	294	70	41	10	10	7	5
1949	3	3	3	37	64	55	10	3	2	6	5	3
1950	2	3	4	35	82	51	14	11	2	4	4	3
1951	2	2	20	49	202	378	133	120	182	277	79	39
1952	23	13	19	105	105	142	58	31	17	10	7	5
1953	3	3	10	63	241	687	88	25	8	10	7	5
1954	3	3	7	45	178	119	27	37	29	49	22	13
1955	8	6	6	76	258	159	94	14	6	13	9	6
1956	4	4	8	27	111	41	52	16	15	7	5	4
1957	3	3	7	53	120	89	14	5	4	8	6	4
1958	3	3	4	67	150	107	106	26	11	8	6	4
1959	3	3	17	36	127	118	25	8	6	13	9	6
1960	4	4	19	20	117	55	9	8	2	3	3	2
1961	2	2	6	13	82	21	5	10	3	39	19	11
1962	7	6	12	60	64	40	7	3	3	4	4	3
1963	2	2	3	9	39	160	116	7	6	3	3	2
1964	2	2	2	20	195	106	21	6	5	8	6	4
1965	3	3	8	63	63	145	63	15	33	24	11	7
1966	4	4	13	26	75	126	44	27	11	9	8	4
1967	3	3	5	33	278	360	27	7	2	3	4	5
1968	5	3	8	16	44	84	26	20	40	46	20	16
1969	9	8	10	110	143	284	234	12	6	7	6	4
1970	0	2	4	19	128	183	39	5	5	6	5	3
1971	3	5	4	39	89	106	13	3	4	7	7	2
1972	2	3	20	73	189	90	31	50	35	29	18	10
1973	9	9	17	52	151	84	14	8	8	6	4	3
1974	2	2	7	63	241	142	19	18	15	14	8	7
1975	2	3	4	36	229	213	83	23	10	10	5	4
1976	4	3	10	37	78	45	16	154	20	11	7	6
1977	4	5	6	15	16	8	3	8	11	10	5	4
1978	3	3	12	46	150	116	65	25	18	12	11	7
1979	5	4	17	46	151	47	11	9	5	4	3	6
1980	4	2	3	43	65	93	11	12	18	15	14	9
1981	9	7	12	16	320	160	49	23	6	6	5	2
1982	0	0	0	20	30	93	21	3	4	7	5	3
1983	2	3	8	34	62	43	14	5	1	4	3	1

LOCAL INFLOW TO SITE #2A (CFS)

1912	2.	4.	63.	111.	144.	156.	191.	104.	60.	32.	16.	10.
1913	1.	6.	24.	191.	154.	122.	137.	47.	42.	26.	12.	7.
1914	1.	5.	24.	91.	65.	63.	49.	17.	13.	34.	17.	10.
1915	1.	6.	33.	71.	391.	604.	500.	191.	140.	43.	19.	21.
1916	0.	14.	69.	100.	149.	404.	227.	-56.	66.	42.	21.	19.
1917	0.	5.	35.	209.	614.	631.	181.	83.	48.	27.	19.	6.
1918	4.	8.	45.	54.	58.	55.	16.	0.	21.	14.	6.	1.
1919	2.	2.	4.	61.	43.	33.	1.	-8.	3.	10.	12.	4.
1920	4.	5.	53.	138.	537.	230.	57.	15.	11.	12.	9.	4.
1921	2.	6.	30.	87.	62.	42.	14.	3.	4.	11.	6.	3.
1922	1.	0.	3.	119.	168.	68.	40.	12.	3.	7.	5.	1.
1923	2.	0.	8.	48.	57.	781.	321.	138.	54.	24.	13.	8.
1924	3.	5.	38.	112.	135.	242.	98.	28.	23.	16.	10.	5.
1925	3.	4.	44.	135.	81.	167.	34.	14.	23.	37.	17.	23.
1926	1.	7.	19.	67.	42.	200.	164.	49.	259.	30.	15.	15.
1927	-3.	7.	52.	96.	507.	617.	186.	7.	339.	-17.	7.	19.
1928	-8.	8.	146.	205.	172.	367.	484.	169.	81.	35.	17.	10.
1929	1.	6.	41.	125.	300.	446.	88.	34.	21.	18.	11.	6.
1930	2.	37.	48.	124.	105.	94.	41.	10.	13.	14.	9.	5.
1931	3.	3.	20.	38.	38.	34.	10.	7.	8.	8.	6.	3.
1932	3.	3.	20.	57.	121.	497.	30.	18.	17.	14.	9.	4.
1933	3.	3.	20.	140.	157.	134.	39.	17.	16.	10.	7.	3.
1934	3.	3.	36.	94.	132.	60.	18.	6.	8.	10.	8.	3.
1935	3.	4.	16.	176.	61.	50.	18.	2.	1.	8.	6.	2.
1936	3.	3.	71.	144.	21.	20.	1.	0.	0.	1.	1.	0.
1937	1.	1.	8.	51.	39.	139.	23.	12.	4.	13.	9.	3.
1938	3.	4.	32.	120.	193.	95.	61.	16.	5.	10.	7.	3.
1939	3.	4.	52.	44.	14.	235.	62.	9.	6.	15.	10.	5.
1940	2.	3.	27.	78.	95.	40.	19.	8.	35.	19.	11.	6.
1941	1.	4.	18.	30.	20.	44.	17.	5.	23.	18.	9.	4.
1942	1.	4.	19.	80.	662.	514.	292.	93.	57.	42.	18.	13.
1943	1.	7.	88.	215.	122.	109.	48.	10.	7.	11.	8.	4.
1944	1.	1.	8.	60.	15.	30.	16.	7.	3.	7.	6.	2.
1945	1.	0.	18.	26.	135.	276.	89.	12.	22.	22.	9.	15.
1946	6.	7.	37.	45.	53.	161.	40.	10.	43.	22.	11.	8.
1947	7.	21.	77.	199.	166.	142.	57.	43.	94.	40.	26.	22.
1948	15.	12.	106.	318.	726.	475.	208.	82.	44.	21.	13.	3.
1949	2.	1.	16.	80.	56.	58.	26.	4.	3.	9.	10.	4.
1950	1.	6.	34.	75.	91.	77.	25.	9.	3.	9.	4.	4.
1951	3.	3.	188.	147.	299.	583.	273.	57.	241.	17.	27.	22.
1952	-3.	24.	112.	311.	175.	151.	114.	75.	43.	21.	14.	7.
1953	5.	9.	84.	143.	421.	1156.	265.	86.	55.	22.	18.	12.
1954	11.	17.	19.	119.	253.	173.	56.	40.	60.	50.	28.	13.
1955	4.	9.	17.	266.	488.	256.	242.	56.	38.	21.	7.	10.
1956	9.	5.	72.	98.	115.	64.	121.	23.	14.	14.	13.	6.
1957	2.	8.	43.	110.	159.	102.	33.	17.	16.	18.	15.	8.
1958	5.	5.	43.	252.	206.	133.	196.	73.	33.	14.	11.	11.
1959	6.	4.	99.	117.	178.	121.	55.	26.	31.	17.	18.	13.
1960	10.	17.	138.	74.	157.	75.	22.	12.	4.	6.	5.	4.
1961	4.	5.	14.	29.	73.	44.	10.	8.	8.	21.	11.	5.
1962	14.	23.	114.	231.	61.	47.	18.	7.	8.	7.	5.	3.
1963	3.	7.	13.	18.	24.	282.	312.	37.	17.	10.	7.	6.
1964	2.	2.	4.	54.	242.	163.	57.	16.	27.	14.	9.	4.
1965	2.	26.	9.	148.	58.	168.	170.	47.	56.	38.	18.	13.
1966	7.	6.	68.	65.	97.	260.	54.	31.	12.	14.	9.	5.
1967	2.	4.	96.	72.	470.	571.	162.	43.	13.	12.	10.	2.
1968	2.	4.	30.	21.	35.	67.	38.	25.	53.	54.	20.	8.
1969	7.	5.	91.	342.	237.	318.	469.	69.	34.	23.	18.	7.
1970	13.	14.	46.	91.	152.	172.	62.	18.	13.	16.	3.	5.
1971	27.	55.	64.	144.	56.	115.	26.	5.	7.	11.	5.	2.
1972	1.	5.	159.	207.	347.	168.	53.	55.	42.	19.	19.	9.
1973	15.	18.	47.	104.	216.	151.	44.	20.	16.	14.	9.	9.
1974	7.	10.	84.	123.	450.	242.	61.	38.	29.	19.	13.	9.
1975	9.	13.	42.	210.	332.	307.	139.	58.	29.	19.	12.	9.
1976	17.	6.	85.	86.	84.	47.	10.	80.	25.	16.	8.	8.
1977	11.	2.	20.	53.	22.	10.	0.	8.	5.	7.	1.	2.
1978	1.	-1.	93.	69.	231.	207.	106.	43.	40.	18.	12.	6.
1979	0.	7.	61.	150.	287.	114.	28.	26.	13.	10.	3.	1.
1980	0.	6.	21.	76.	63.	93.	9.	11.	13.	16.	5.	9.
1981	3.	7.	21.	17.	332.	292.	104.	52.	15.	15.	9.	2.
1982	2.	2.	13.	86.	29.	97.	45.	9.	14.	12.	9.	7.
1983	9.	8.	32.	30.	30.	24.	14.	-2.	-1.	5.	10.	8.

CHAIN LAKES LOCAL INFLOW (CFS)

1912	0.	0.	4.	10.	15.	18.	19.	9.	6.	3.	2.	1.
1913	1.	0.	2.	16.	19.	15.	12.	7.	4.	3.	2.	1.
1914	1.	0.	2.	8.	8.	8.	5.	2.	1.	3.	1.	1.
1915	0.	0.	2.	6.	44.	58.	39.	15.	12.	4.	2.	1.
1916	1.	0.	5.	10.	16.	47.	22.	6.	10.	7.	3.	1.
1917	1.	1.	3.	16.	59.	65.	15.	6.	5.	1.	1.	0.
1918	0.	0.	3.	5.	8.	7.	2.	1.	2.	2.	1.	1.
1919	0.	0.	1.	5.	7.	3.	0.	1.	0.	1.	1.	0.
1920	0.	0.	3.	12.	53.	25.	9.	2.	1.	1.	1.	0.
1921	0.	0.	2.	8.	9.	6.	2.	1.	1.	1.	1.	0.
1922	0.	0.	0.	10.	19.	9.	4.	1.	0.	1.	0.	0.
1923	0.	0.	1.	5.	7.	76.	24.	9.	5.	1.	1.	1.
1924	0.	0.	3.	10.	15.	25.	9.	6.	2.	2.	1.	1.
1925	0.	0.	3.	13.	12.	18.	4.	2.	2.	5.	2.	1.
1926	1.	1.	2.	7.	5.	20.	13.	4.	21.	12.	4.	2.
1927	1.	1.	4.	9.	50.	59.	17.	10.	27.	23.	6.	3.
1928	2.	1.	9.	17.	21.	37.	35.	10.	7.	3.	1.	1.
1929	1.	0.	3.	11.	33.	46.	8.	3.	2.	1.	1.	0.
1930	0.	0.	3.	12.	14.	12.	5.	2.	1.	1.	1.	0.
1931	0.	0.	2.	4.	5.	5.	1.	1.	1.	0.	0.	0.
1932	0.	0.	2.	5.	14.	51.	4.	2.	2.	1.	1.	0.
1933	0.	0.	2.	12.	19.	16.	5.	2.	2.	1.	1.	0.
1934	0.	0.	3.	8.	16.	8.	2.	1.	1.	1.	1.	0.
1935	0.	0.	1.	13.	7.	7.	3.	1.	0.	1.	1.	0.
1936	0.	0.	4.	12.	3.	3.	0.	0.	0.	0.	0.	0.
1937	0.	0.	1.	4.	5.	15.	3.	1.	1.	2.	1.	1.
1938	0.	0.	2.	10.	25.	13.	7.	2.	0.	1.	1.	0.
1939	0.	0.	3.	4.	3.	24.	6.	1.	1.	2.	1.	1.
1940	0.	0.	2.	7.	11.	6.	2.	1.	3.	5.	2.	1.
1941	1.	0.	2.	3.	3.	6.	2.	1.	3.	5.	2.	1.
1942	1.	1.	2.	7.	61.	58.	25.	10.	10.	5.	2.	1.
1943	1.	0.	5.	19.	14.	13.	5.	2.	1.	1.	1.	0.
1944	0.	0.	1.	5.	3.	4.	2.	1.	0.	1.	0.	0.
1945	0.	0.	1.	2.	17.	29.	8.	2.	2.	3.	1.	1.
1946	1.	0.	3.	4.	7.	20.	5.	2.	4.	3.	2.	1.
1947	1.	0.	6.	17.	21.	19.	6.	3.	9.	6.	2.	1.
1948	1.	1.	6.	24.	71.	47.	19.	8.	4.	1.	1.	0.
1949	0.	0.	1.	8.	8.	8.	3.	1.	0.	1.	1.	0.
1950	0.	0.	2.	7.	11.	9.	3.	1.	0.	1.	1.	0.
1951	0.	0.	10.	12.	32.	58.	25.	9.	28.	20.	6.	3.
1952	2.	1.	7.	25.	18.	19.	11.	6.	4.	1.	1.	0.
1953	0.	0.	5.	13.	42.	108.	23.	8.	4.	1.	1.	0.
1954	0.	0.	2.	10.	28.	19.	6.	5.	6.	5.	2.	1.
1955	1.	1.	2.	21.	47.	27.	20.	5.	3.	2.	1.	1.
1956	0.	0.	5.	8.	15.	7.	11.	3.	2.	1.	1.	0.
1957	0.	0.	3.	10.	18.	13.	4.	2.	1.	1.	1.	0.
1958	0.	0.	3.	19.	23.	16.	18.	6.	3.	1.	1.	0.
1959	0.	0.	6.	10.	20.	16.	6.	2.	3.	2.	1.	1.
1960	0.	0.	8.	6.	18.	9.	3.	1.	0.	1.	0.	0.
1961	0.	0.	2.	3.	10.	5.	1.	2.	1.	6.	2.	1.
1962	1.	1.	7.	18.	8.	6.	2.	1.	1.	1.	1.	0.
1963	0.	0.	1.	2.	4.	28.	25.	3.	2.	1.	0.	0.
1964	0.	0.	1.	5.	28.	18.	5.	2.	2.	1.	1.	0.
1965	0.	0.	1.	13.	8.	20.	14.	4.	6.	4.	2.	1.
1966	1.	0.	5.	6.	11.	25.	7.	4.	2.	1.	1.	0.
1967	0.	0.	5.	7.	48.	57.	14.	3.	1.	1.	1.	0.
1968	0.	0.	2.	3.	5.	10.	4.	3.	6.	3.	2.	1.
1969	1.	0.	6.	27.	25.	38.	38.	5.	3.	1.	1.	0.
1970	0.	0.	3.	7.	18.	23.	7.	2.	1.	1.	1.	0.
1971	0.	0.	4.	12.	10.	15.	3.	1.	1.	1.	1.	0.
1972	0.	0.	9.	17.	34.	17.	6.	6.	5.	2.	1.	1.
1973	0.	0.	4.	10.	24.	15.	4.	2.	2.	1.	1.	0.
1974	0.	0.	5.	12.	44.	25.	5.	4.	3.	2.	1.	1.
1975	0.	0.	3.	15.	36.	33.	14.	5.	3.	1.	1.	0.
1976	0.	0.	5.	8.	11.	6.	2.	11.	3.	2.	1.	1.
1977	0.	0.	2.	5.	3.	1.	0.	1.	1.	1.	1.	0.
1978	0.	0.	6.	8.	22.	21.	10.	4.	4.	2.	1.	1.
1979	0.	0.	4.	12.	27.	10.	3.	2.	1.	1.	0.	0.
1980	0.	0.	1.	8.	9.	13.	1.	2.	2.	2.	1.	1.
1981	0.	0.	2.	2.	45.	28.	9.	5.	2.	2.	1.	1.
1982	0.	0.	1.	7.	4.	13.	4.	1.	1.	1.	1.	0.
1983	0.	0.	3.	4.	6.	5.	2.	0.	0.	1.	1.	0.

APPENDIX B

LISTINGS OF COMPUTER PROGRAMS FOR
THE ASSESSMENT OF RESERVOIR SCHEMES

	<u>Listing</u>
Offstream Reservoir Model	B1
Onstream Reservoir Model	B2


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1 CCC PROGRAM 'PS.OFFRES' COMPUTES WATER ALLOCATION GIVEN
2 CCC INFLOWS, DEMANDS AND AN OFFSTREAM RESERVOIR.
3 CCC VARIABLES AND THEIR DEFINITIONS FOLLOW.
4 CCC TO RUN: RUN C.OFFRES 1=RESDATA 2=INFLOWS 3=EVAP 4=PRECIP
5 CCC B=LOCAL INFLOWS 6=5-DAY 1'S 7=OUTPUT 8=D/S FLOWS 9=RES.ELS T=10S
6 CCC
7 CCC VARIABLE UNIT DEFINITION
8 CCC
9 C ARELAS ACRES PREVIOUS MONTH'S SURFACE AREA
10 C AREPRE(12)ACRES PRESENT SURFACE AREA OF RESERVOIR
11 C DELTA AC-FT STOMAX - STOPRE
12 C DEMAND(12) CFS WATER DEMAND EACH MONTH
13 C DEMAND(12)AC-FT 90% WATER DEMAND EACH MONTH
14 C DEM28 AC-FT WATER DEMAND FOR 28-DAY FEBRUARY
15 C DICE(12) FT DEPTH OF ICE IN RESERVOIR
16 C DIVCAP CFS DIVERSION CAPACITY TO RESERVOIR
17 C DIVCP6(6) AC-FT MAX DIV. VOL. TO RES. 6-DAY PERIODS
18 C DSFLOW(12) CFS TOTAL FLOW D/S OF RESERVOIR
19 C D28 AC-FT DEMAND IN FEBRUARY FOR LEAP YEAR
20 C D288 AC-FT 90% DEMAND IN FEB. FOR LEAP YEAR
21 C ELPRE(12) FT PRESENT WATER ELEVATION OF RESERVOIR
22 C EVAP(12) MM EVAPORATION, EACH MONTH
23 C GONE AC-FT VOL. OF INFLOW RELEASED FOR RIP + DEM
24 C IC CHECK ON LEAP YEAR
25 C INFIN - LAST MONTH EACH YEAR DIV.CANAL OPERATES
26 C INSTA - FIRST MONTH EACH YEAR DIV.CANAL OPERATES
27 C IY - YEAR OF RES. INFLOW DATA
28 C IYV - YEAR OF PCENT DATA
29 C KDEM(12) - COUNTER, # OF MONTHS 90% OF DEMAND SHORT
30 C KDIV(12) - COUNTER, #MONTHS DIV. DEPENDANT ON CANAL CAP
31 C KRIP(12) - COUNTER, # OF MONTHS 90% OF RIPARIAN SHORT
32 C KSPI(12) CFS COUNTER, NUMBER OF MONTHS SPILL REQ'D
33 C LY - #1 IF LEAP YEAR, OTHERWISE =0
34 C NDAYS(12) - NUMBER OF DAYS EACH MONTH
35 C NEL - NO. OF ELEVATION-AREA-VOLUME POINTS
36 C NET(12) AC-FT PRECIP - EVAP EACH MONTH
37 C OUTDEM(12)AC-FT ACTUAL DEMAND RELEASED EACH MONTH
38 C OUTDIV(12)AC-FT DIVERSION INTO RESERVOIR EACH MONTH
39 C OUTRIP(12)AC-FT ACTUAL RIPARIAN RELEASED EACH MONTH
40 C OUTSPI(12)AC-FT SPILL FROM RESERVOIR EACH MONTH
41 C PCENT(6,12) - FRACTION OF MONTHLY VOLUME IN 6-DAY PERIODS
42 C PRECIP(12) MM PRECIPITATION, EACH MONTH
43 C QIN(12) CFS INFLOW EACH MONTH
44 C QINR(12) CFS LOCAL INFLOW TO RESERVOIR EACH MONTH
45 C OP AC-FT QIN + OUTSPI
46 C O1 AC-FT QIN - RIPAR; INFLOW - RIPARIAN
47 C O2 AC-FT Q1 - DEMAND
48 C O4 AC-FT STOLIV + O1 DIFF OF LIVE STORAGE, NET RIP
49 C O5 AC-FT STOLIV + O2 DIFF OF LIVE STORAGE, NET DEM
50 C O6 AC-FT ACTUAL VOL.DIVERTED TO RES.(VOLDIV OR DELTA)
51 C RESARE(20)ACRES RESERVOIR SURFACE AREA POINTS
52 C RESEL(20) FT RESERVOIR ELEVATION POINTS
53 C RESVOL(20)AC-FT RESERVOIR GROSS VOLUME POINTS
54 C RIPAR(12) CFS RIPARIAN FLOW EACH MONTH
55 C RIPAR6(12)AC-FT 90% RIPARIAN EACH MONTH
56 C RIP28 AC-FT RIPARIAN FLOW FOR 28-DAY FEBRUARY
57 C R28 AC-FT RIPARIAN FLOW FOR FEB. IN A LEAP YEAR
58 C R288 AC-FT 90% RIPARIAN FOR FEB. IN A LEAP YEAR
59 C SPILL AC-FT SPILL FROM RESERVOIR
60 C STOICE(12)AC-FT STORAGE TAKEN UP BY ICE
61 C STOLAS AC-FT PREVIOUS MONTH'S STORAGE VOLUME
62 C STOLIV AC-FT STOMAX - STOPRE LIVE STORAGE AVAILABLE
63 C STOMAX AC-FT MAXIMUM GROSS STORAGE (DEAD + LIVE)
64 C STOMIN AC-FT DEAD STORAGE
65 C STOPRE(12)AC-FT PRESENT RESERVOIR GROSS VOLUME
66 C STOSTA AC-FT STARTING RESERVOIR VOLUME
67 C SURPLU(12)AC-FT EXCESS INFLOW THAT CANNOT BE STORED
68 C VOLDIV AC-FT MAX.DIV.VOL.AVAIL.DUE TO DIV.CANAL CAP.
69 C VOLIN AC-FT AVAIL VOL. FOR DIVERSION TO RES
70 C WHET AC-FT ACCUMULATED PRECIP-EVAP IN WINTER MONTHS
71 C YEAR - YEAR BEING ANALYZED
72 C
73 C INTEGER YEAR
74 C REAL NET
75 C DIMENSION RESEL(20),RESARE(20),RESVOL(20),RIPAR(12),DEMAND(12)
76 C DIMENSION NDAYS(12),KRIP(12),KDEM(12),OUTRIP(12),OUTDEM(12)
77 C DIMENSION SURPLU(12),OUTSPI(12),STOPRE(12),QIN(12),OUTDIV(12)
78 C DIMENSION NET(12),ELPRE(12),AREPRE(12),EVAP(12),PRECIP(12)
79 C DIMENSION KSPI(12),DICE(12),QINR(12),STOICE(12),DSFLOW(12)
80 C DIMENSION RIPAR6(12),DEMAND6(12),KDIV(12),PCENT(6,12)
81 C DIMENSION DIVCP6(6)
82 C DATA NDAYS(1)/31/,NDAYS(2)/28/,NDAYS(3)/31/,NDAYS(4)/30/
83 C DATA NDAYS(6)/31/,NDAYS(8)/30/,NDAYS(7)/31/,NDAYS(9)/31/
84 C DATA NDAYS(10)/30/,NDAYS(10)/31/,NDAYS(11)/30/,NDAYS(12)/31/
85 C
86 C READ(1,100)STOSTA, DIVCAP, STOMAX,STOMIN,NEL
87 C 100 FORMAT( 4F10.0, 14)
88 C DO 10 I=1,NEL
89 C READ(1,100) RESEL(I), RESARE(I), RESVOL(I)
90 C 10 CONTINUE
91 C READ(6,105) INSTA,INFIN
92 C 105 FORMAT(2I4)
93 C DO 11 I=1,12
94 C READ(1,100) RIPAR(I),DEMAND(I),DICE(I)
95 C RIPAR(I)=RIPAR(I)*1.9836*NDAYS(I)
96 C RIPAR6(I)=0.9*RIPAR(I)
97 C DEMAND(I)=DEMAND(I)*1.9836*NDAYS(I)
98 C DEMAND6(I)=0.9*DEMAND(I)
99 C KDIV(I)=0
100 C KRIP(I)=0
101 C KDEM(I)=0
102 C KSPI(I)=0
103 C 11 CONTINUE
104 C
105 C RIP28=RIPAR(2)
106 C DEM28=DEMAND(2)
107 C R28=RIPAR(2)*28/28
108 C R288=0.9*R28
109 C D28=DEMAND(2)*28/28
110 C D288=0.9*D28
111 C STOLAS=STOSTA
112 C
113 C CALL LININT(ELPRE(1),ARELAS,STOLAS,NEL,RESEL,RESARE,RESVOL)
114 C WRITE(7,200)STOMAX,STOSTA,DIVCAP
115 C 200 FORMAT(' RESERVOIR CAPACITY = ',F8.0,' AC-FT',/, 'STARTING RESERVOI
116 C R VOLUME = ',F8.0,' AC-FT',/, 'DIVERSION CANAL CAPACITY = ',F8.0,'
117 C CFS',/)
118 C WRITE(7,201)
119 C 201 FORMAT(' MONTH GROSS ADD.ICE U/S LOCAL PRECIP RIPAR DEM
120 C AND DIVERS SURPLUS SPILL')

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121 WRITE(7,203)
122 203 FORMAT(' STORAGE STORAGE INFLOW INFLOW - EVAP VOLUME VOL
123 =UME TO RES. DEFICIT VOLUME')
124 WRITE(7,204)
125 204 FORMAT(' AC-FT AC-FT AC-FT AC-FT AC-FT AC-FT AC-
126 =FT AC-FT AC-FT AC-FT')
127 C
128 DO 20 I=1,72
129 READ(2,101) YEAR, (QIN(J),J=1,12)
130 101 FORMAT(18,12F8.0)
131 READ(3,102) (EVAP(J),J=1,12)
132 102 FORMAT(4X,12F8.0)
133 READ(4,103) (PRECIP(J),J=1,12)
134 103 FORMAT(5X,12F8.0)
135 READ(5,104) IY, (QINR(J),J=1,12)
136 IF(YEAR.NE.IY) GOTO 500
137 WRITE(7,203) YEAR
138 203 FORMAT(18,' ')
139 LV=0
140 NDAYS(2)=28
141 IC=YEAR/4+4
142 IF(IC.EQ.YEAR) LV=1
143 DO 18 K=1,8
144 READ(6,104) IY, (PCENT(K,J),J=1,12)
145 104 FORMAT(18,12F8.0)
146 18 CONTINUE
147 IF(IY.NE.YEAR) GOTO 500
148 C
149 RIPAR(2)=RIP28
150 DEMAND(2)=DEM28
151 C
152 DO 21 L=1,12
153 IF(L.EQ.2.AND.LV.EQ.1) RIPAR(2)=R29
154 IF(L.EQ.2.AND.LV.EQ.1) DEMAND(2)=D29
155 IF(LV.EQ.1) NDAYS(2)=28
156 STOPRE(L)=STOLAS
157 CC
158 CC CONVERT MONTHLY RATES TO MONTHLY VOLUMES
159 CC
160 QIN(L)=QIN(L)*1.8835*NDAYS(L)
161 QINR(L)=QINR(L)*1.8835*NDAYS(L)
162 C
163 NET(L)=(PRECIP(L)-EVAP(L))/(28.4*12)*ARELAS
164 IF(L.GT.3.AND.L.LT.11) GOTO 25
165 WNET=WNET+NET(L)
166 NET(L)=0.0
167 25 STOICE(L)=DICE(L)*ARELAS
168 STOPRE(L)=STOPRE(L)-STOICE(L)
169 IF(L.EQ.4) NET(L)=NET(L)+WNET
170 IF(L.EQ.4) WNET=0.0
171 STOPRE(L)=STOPRE(L)+NET(L)+QINR(L)
172 IF(STOPRE(L).LT.0.0) STOPRE(L)=0.0
173 OUTSPI(L)=0.0
174 SURPLU(L)=0.0
175 OUTDIV(L)=0.0
176 OUTTRIP(L)=0.0
177 OUTDEM(L)=0.0
178 SPILL=STOPRE(L)-(STOMAX-STOICE(L))
179 IF(SPILL.LE.0.0) GOTO 19
180 KSPI(L)=KSPI(L)+1
181 OUTSPI(L)=SPILL
182 STOPRE(L)=(STOMAX-STOICE(L))
183 CC
184 CC RIPARIAN FLOW REQUIREMENT
185 CC
186 19 OP=QIN(L)+OUTSPI(L)
187 O1=OP-RIPAR(L)
188 IF(O1.LT.0.0) GOTO 30
189 OUTTRIP(L)=RIPAR(L)
190 CC
191 CC DEMAND FLOW REQUIREMENT
192 CC
193 O2=O1-DEMAND(L)
194 IF(O2.LT.0.0) GOTO 31
195 OUTDEM(L)=DEMAND(L)
196 CC
197 CC CHECK ON RES VOL : UP TO CAPACITY?
198 CC
199 DELTA=(STOMAX-STOICE(L))-STOPRE(L)
200 IF(DELTA.LT.0.0) O2=O2-DELTA
201 IF(DELTA.LE.0.0) GOTO 40
202 CC
203 CC ATTEMPT TO FILL RESERVOIR
204 CC
205 IF(L.LT.INSTA.OR.L.GT.INFIN) SURPLU(L)=O2
206 IF(L.LT.INSTA.OR.L.GT.INFIN) GOTO 50
207 VOLDIV=0.0
208 VOLDDW=0.0
209 IF(L.EQ.2.AND.LV.EQ.1) GOTO 51
210 DO 50 M=1,5
211 DIVCPS(M)=DIVCAP*1.8835*5.
212 GONE=(RIPAR(L)+DEMAND(L))*(5/NDAYS(L))
213 PCENT(M,L)=PCENT(M,L)+QIN(L)-GONE
214 50 CONTINUE
215 DIVCPS(5)=DIVCAP*1.8835*(NDAYS(L)-35)
216 GONE=(RIPAR(L)+DEMAND(L))*(NDAYS(L)-28)/NDAYS(L)
217 PCENT(5,L)=PCENT(5,L)+QIN(L)-GONE
218 GOTO 53
219 51 DO 52 M=1,5
220 DIVCPS(M)=DIVCAP*1.8835*5.
221 GONE=(R29+D29)*(5/28)
222 PCENT(M,L)=PCENT(M,L)+QIN(L)-GONE
223 52 CONTINUE
224 DIVCPS(5)=DIVCAP*1.8835*4.
225 GONE=(R29+D29)*4/28
226 PCENT(5,L)=PCENT(5,L)+QIN(L)-GONE
227 53 VOLIN=0.0
228 DO 55 M=1,5
229 VOLIN=VOLIN+PCENT(M,L)
230 IF(DIVCPS(M).LT.PCENT(M,L)) GOTO 54
231 VOLDIV=VOLDIV+PCENT(M,L)
232 GOTO 55
233 54 VOLDIV=VOLDIV+DIVCPS(M)
234 55 CONTINUE
235 O5=DELTA
236 IF(VOLDIV.LT.DELTA) O5=VOLDIV
237 IF(O5.EQ.VOLDIV.AND.VOLIN.GT.VOLDIV) KDIV(L)=KDIV(L)+1
238 STOPRE(L)=STOPRE(L)+O5
239 OUTDIV(L)=O5
240 SURPLU(L)=VOLIN-O5

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1 CCC PROGRAM 'PS ONRES' COMPUTES WATER ALLOCATION GIVEN
2 CCC INFLOWS, DEMANDS AND AN ONSTREAM RESERVOIR.
3 CCC VARIABLES AND THEIR DEFINITIONS FOLLOW.
4 CCC TO RUN: RUN C ONRES 1=RESDATA 2=INFLOWS 3=EVAP 4=PRECIP
5 CCC 5=LOCAL INFLOWS 7=OUTPUT 8=0/5 9=LOWS 9=RES ELS 7=105
6 CCC
7 CCC VARIABLE UNIT DEFINITION
8 CCC
9 C ARELAS ACRES PREVIOUS MONTH'S SURFACE AREA
10 C AREPRE(12) ACRES PRESENT SURFACE AREA OF RESERVOIR
11 C DELTA AC-FT STOMAX - STOICE - STOPRE
12 C DEMAND(12) CFS WATER DEMAND EACH MONTH
13 C DEMAN2(12) CFS WATER DEMAND, NORTH END, EACH MONTH
14 C DEMAN3(12) AC-FT 90% WATER DEMAND, NORTH END, EACH MONTH
15 C DEMA29(12) AC-FT WATER DEMAND FOR 29-DAY FEBRUARY
16 C DEM28 AC-FT WATER DEMAND, NORTH END, FOR 28-DAY FEB
17 C DEM29 AC-FT DEMAND, NORTH END, FOR 29-DAY FEB
18 C DEM299 AC-FT 90% DEMAND, NORTH END, FOR 29-DAY FEB
19 C D29 AC-FT DEMAND FOR 29-DAY FEB
20 C D299 AC-FT 90% DEMAND FOR 29-DAY FEB
21 C DICE(12) FT DEPTH OF ICE IN RESERVOIR
22 C DSFLOW(12) CFS TOTAL FLOW D/S OF RESERVOIR
23 C ELPRE(12) FT PRESENT WATER ELEVATION OF RESERVOIR
24 C EVAP(12) MM EVAPORATION, EACH MONTH
25 C IC - CHECK ON LEAP YEAR
26 C IY - YEAR OF RES. INFLOW DATA
27 C KDEM(12) - COUNTER, NUMBER OF MONTHS DEMAND SHORTAGE
28 C KDE2(12) - COUNTER, NUMBER OF MONTHS NORTH DEMAND SHORT
29 C KRIP(12) - COUNTER, NUMBER OF MONTHS RIPARIAN SHORT
30 C KSP1(12) - COUNTER, NUMBER OF MONTHS SPILL REQ'D
31 C LY - 1 IF LEAP YEAR, OTHERWISE =0
32 C NDAYS(12) - NUMBER OF DAYS EACH MONTH
33 C NEL - NO. OF ELEVATION-AREA-VOLUME POINTS
34 C NET(12) AC-FT PRECIP - EVAP EACH MONTH
35 C OUTDEM(12) AC-FT ACTUAL DEMAND RELEASED EACH MONTH
36 C OUTDE2(12) AC-FT ACTUAL DEMAND RELEASED NORTH END EACH MONTH
37 C OUTRIP(12) AC-FT ACTUAL RIPARIAN RELEASED EACH MONTH
38 C OUTSPI(12) AC-FT SPILL FROM RESERVOIR EACH MONTH
39 C PRECIP(12) MM PRECIPITATION, EACH MONTH
40 C QIN(12) CFS INFLOW EACH MONTH
41 C QINR(12) CFS LOCAL INFLOW TO RESERVOIR EACH MONTH
42 C OTIN(12) AC-FT QIN + QINR, TOTAL INFLOW TO RESERVOIR
43 C O1 AC-FT SPILL - RIPAR, SPILL - RIPARIAN
44 C O2 AC-FT O1 - RIPARIAN - DEMAND
45 C O3 AC-FT O2 - RIPARIAN - DEMAND - DEMAN2
46 C O4 AC-FT STOLIIV + O1 DIFF OF LIVE STORAGE, SPILL-RIP
47 C O5 AC-FT STOLIIV + O2 DIFF OF LIVE STORAGE, SPILL-DEM
48 C O6 AC-FT STOLIIV + O3 DIFF OF LIVE STORAGE, SPILL-DE2
49 C O7 AC-FT
50 C RESARE(20) ACRES RESERVOIR SURFACE AREA POINTS
51 C RESEL(20) FT RESERVOIR ELEVATION POINTS
52 C RESVOL(20) AC-FT RESERVOIR GROSS VOLUME POINTS
53 C RIPAR(12) CFS RIPARIAN FLOW EACH MONTH
54 C RIP28 AC-FT 90% RIPARIAN EACH MONTH
55 C RIP29 AC-FT RIPARIAN FLOW FOR 28-DAY FEBRUARY
56 C R29 AC-FT RIPARIAN FOR 29-DAY FEB
57 C R299 AC-FT 90% RIPARIAN FOR 29-DAY FEB
58 C SPILL AC-FT SPILL FROM RESERVOIR
59 C STOICE(12) AC-FT STORAGE TAKEN UP BY ICE
60 C STOLAS AC-FT PREVIOUS MONTH'S STORAGE VOLUME
61 C STOLIIV AC-FT STOMAX - STOPRE LIVE STORAGE AVAILABLE
62 C STOMAX AC-FT MAXIMUM GROSS STORAGE (DEAD + LIVE)
63 C STOMIN AC-FT DEAD STORAGE
64 C STOPRE(12) AC-FT PRESENT RESERVOIR GROSS VOLUME
65 C STOSTA AC-FT STARTING RESERVOIR VOLUME
66 C SURPLU(12) AC-FT EXCESS INFLOW THAT CANNOT BE STORED
67 C WNEY AC-FT ACCUMULATED PRECIP-EVAP IN WINTER MONTHS
68 C YEAR - YEAR BEING ANALYZED
69 C
70 C INTEGER YEAR
71 REAL NET
72 DIMENSION RESEL(20), RESARE(20), RESVOL(20), RIPAR(12), DEMAND(12)
73 DIMENSION NDAYS(12), KRIP(12), KDEM(12), OUTRIP(12), OUTDEM(12)
74 DIMENSION SURPLU(12), OUTSPI(12), STOPRE(12), QIN(12), OTIN(12)
75 DIMENSION NET(12), ELPRE(12), AREPRE(12), EVAP(12), PRECIP(12)
76 DIMENSION KSP1(12), DICE(12), QINR(12), STOICE(12), DEMAN2(12)
77 DIMENSION OUTDE2(12), KDE2(12), DSFLOW(12), DEMAN3(12), RIPAR3(12)
78 DIMENSION DEMA29(12)
79 DATA NDAYS(1)/31/, NDAYS(2)/28/, NDAYS(3)/31/, NDAYS(4)/30/
80 DATA NDAYS(5)/31/, NDAYS(6)/30/, NDAYS(7)/31/, NDAYS(8)/31/
81 DATA NDAYS(9)/30/, NDAYS(10)/31/, NDAYS(11)/30/, NDAYS(12)/31/
82 C
83 READ(1,100) STOSTA, STOMAX, STOMIN, NEL
84 FORMAT( 3F10.0, 14)
85 DO 10 I=1, NEL
86 READ(1,100) RESEL(I), RESARE(I), RESVOL(I)
87 CONTINUE
88 DO 11 I=1, 12
89 READ(1,104) RIPAR(I), DEMAND(I), DEMAN2(I), DICE(I)
90 FORMAT( 4F10.0)
91 RIPAR(I)=RIPAR(I)+1.9835*NDAYS(I)
92 RIPAR3(I)=0.9*RIPAR(I)
93 DEMAND(I)=DEMAND(I)+1.9835*NDAYS(I)
94 DEMAN2(I)=0.9*DEMAND(I)
95 DEMAN3(I)=DEMAN2(I)+1.9835*NDAYS(I)
96 DEMA29(I)=0.9*DEMAN2(I)
97 KRIP(I)=0
98 KDEM(I)=0
99 KDE2(I)=0
100 KSP1(I)=0
101 CONTINUE
102 C
103 RIP28=RIPAR(2)
104 DEM28=DEMAND(2)
105 DEM29=DEMAN2(2)
106 R28=RIPAR(2)*29/28
107 R29=0.9*R28
108 D28=DEMAND(2)*29/28
109 D29=0.9*D28
110 DEM299=DEMAN2(2)*29/28
111 DEM299=0.9*DEM29
112 STOLAS=STOSTA
113 C
114 CALL LINIT(ELPRE(1), ARELAS, STOLAS, NEL, RESEL, RESARE, RESVOL)
115 WRITE(7,200) STOMAX, STOSTA
116 FORMAT('RESERVOIR CAPACITY = ', F8.0, ' AC-FT', /, 'STARTING RESERVOI
117 R VOLUME = ', F8.0, ' AC-FT', /)
118 WRITE(7,201)
119 FORMAT('MONTH GROSS ADD ICE U/S LOCAL PRECIP RIPAR SOU
120 TH NORTH SURPLUS SPILL')

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121 WRITE(7,202)
122 FORMAT(' ', STORAGE STORAGE INFLOW INFLOW - EVAP VOLUME DEM
123 'ANC DEMAND DEFICIT VOLUME')
124 WRITE(7,204)
125 FORMAT(' ', AC-FT AC-FT AC-FT AC-FT AC-FT AC-FT AC-FT AC-FT AC-
126 'FT AC-FT AC-FT AC-FT')
127 C
128 DD 20 I=1,72
129 READ(2,101) YEAR, (QIN(J), J=1,12)
130 101 FORMAT(15,12F5.0)
131 READ(3,102) (EVAP(J), J=1,12)
132 102 FORMAT(12,12F5.0)
133 READ(4,103) (PRECIP(J), J=1,12)
134 103 FORMAT(12,12F5.0)
135 READ(5,104) (QINR(J), J=1,12)
136 IF YEAR NE IV, GOTD 800
137 WRITE(7,203) YEAR
138 203 FORMAT(15,' ')
139 C
140 LY=0
141 NDAYS(2)=28
142 IC=YEAR/4+4
143 IF IC.EQ.YEAR, LY=1
144 RIPAR(2)=RIP28
145 DEMAND(2)=DEM28
146 DEMAN2(2)=DE228
147 C
148 DD 21 L=1,12
149 IF L.EQ.2 AND LY.EQ.1, RIPAR(2)=R28
150 IF L.EQ.2 AND LY.EQ.1, DEMAND(2)=D28
151 IF L.EQ.2 AND LY.EQ.1, DEMAN2(2)=DE28
152 IF L.EQ.2 AND LY.EQ.1, NDAYS(2)=28
153 STOPRE(L)=STGLAS
154 CC
155 CC CONVERT MONTHLY RATES TO MONTHLY VOLUMES
156 CC
157 QIN(L)=QIN(L)*1.8635*NDAYS(L)
158 QINR(L)=QINR(L)*1.8635*NDAYS(L)
159 QTIN(L)=QIN(L)+QINR(L)
160 C
161 NET(L)=(PRECIP(L)-EVAP(L))/(25.4*12)*ARELAS
162 IF L.GT.3 AND L.LT.11, GOTD 25
163 WNET=WNET-NET(L)
164 NET(L)=0.0
165 25 STOICE(L)=DICE(L)*ARELAS
166 STOPRE(L)=STOPRE(L)-STOICE(L)
167 IF L.EQ.4, NET(L)=WNET-L*WNET
168 IF L.EQ.4, WNET=0.0
169 STOPRE(L)=STOPRE(L)-NET(L)+QTIN(L)
170 IF STOPRE(L).LT.0.0, STOPRE(L)=0.0
171 SPILL=0.0
172 OUTSPI(L)=0.0
173 SURPLU(L)=0.0
174 OUTRIP(L)=0.0
175 OUTDEM(L)=0.0
176 OUTDE2(L)=0.0
177 SPILL=STOPRE(L)-STOMAX-STOICE(L)
178 IF (SPILL.LE.0.0) GOTD 30
179 KSPI(L)=KSPI(L)+1
180 OUTSPI(L)=SPILL
181 STOPRE(L)=STOMAX-STOICE(L)
182 CC
183 CC RIPARIAN FLOW REQUIREMENT
184 CC
185 Q1=SPILL-RIPAR(L)
186 IF (Q1.LT.0.0) GOTD 32
187 OUTRIP(L)=RIPAR(L)
188 SPILL=Q1
189 CC
190 CC DEMAND FLOW REQUIREMENTS
191 CC
192 Q2=SPILL-DEMAND(L)
193 IF (Q2.LT.0.0) GOTD 31
194 OUTDEM(L)=DEMAND(L)
195 SPILL=Q2
196 Q3=SPILL-DEMAN2(L)
197 IF (Q3.LT.0.0) GOTD 33
198 OUTDE2(L)=DEMAN2(L)
199 SURPLU(L)=Q3
200 GOTD 90
201 CC
202 CC SHORTAGE OF INFLOW, RELEASE FROM RESERVOIR TO MEET RIP.
203 CC
204 30 IF (STOPRE(L).GT.STOMIN) Q1=0.0-RIPAR(L)
205 IF (STOPRE(L).GT.STOMIN) GOTD 32
206 IF (L.EQ.2 AND LY.EQ.1) GOTD 34
207 IF (RIPAR(L).NE.0.0 AND OUTRIP(L).LT.RIPAR(L)) KRIP(L)=KRIP(L)+1
208 IF (DEMAND(L).NE.0.0 AND OUTDEM(L).LT.DEMAND(L)) KDEM(L)=KDEM(L)+1
209 IF (DEMAN2(L).NE.0.0 AND OUTDE2(L).LT.DEMAN2(L)) KDE2(L)=KDE2(L)+1
210 GOTD 35
211 34 IF (RIPAR(L).NE.0.0 AND OUTRIP(L).LT.R288) KRIP(L)=KRIP(L)+1
212 IF (DEMAND(L).NE.0.0 AND OUTDEM(L).LT.D288) KDEM(L)=KDEM(L)+1
213 IF (DEMAN2(L).NE.0.0 AND OUTDE2(L).LT.D288) KDE2(L)=KDE2(L)+1
214 35 SURPLU(L)=0.0-RIPAR(L)-DEMAND(L)-DEMAN2(L)
215 GOTD 90
216 32 STOLIV=STOPRE(L)-STOMIN
217 Q4=STOLIV+Q1
218 IF (Q4.LT.0.0) GOTD 51
219 STOPRE(L)=STOPRE(L)+Q1
220 OUTRIP(L)=RIPAR(L)
221 OUTSPI(L)=OUTSPI(L)-Q1
222 Q2=0.0-DEMAND(L)
223 CC
224 CC SHORTAGE OF INFLOW, RELEASE FROM RESERVOIR TO MEET DEMAND
225 CC
226 31 STOLIV=STOPRE(L)-STOMIN
227 Q5=STOLIV+Q2
228 IF (Q5.LT.0.0) GOTD 52
229 STOPRE(L)=STOPRE(L)+Q2
230 OUTDEM(L)=DEMAND(L)
231 OUTSPI(L)=OUTSPI(L)-Q2
232 Q3=0.0-DEMAN2(L)
233 33 STOLIV=STOPRE(L)-STOMIN
234 Q7=STOLIV+Q3
235 IF (Q7.LT.0.0) GOTD 53
236 STOPRE(L)=STOPRE(L)+Q3
237 OUTDE2(L)=DEMAN2(L)
238 OUTSPI(L)=OUTSPI(L)-Q3
239 GOTD 90
240 C

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241      GOTO 90
242  CC
243  CC  SHORTAGE OF INFLOW, RELEASE FROM RES. TO MEET RIP.
244  CC
245  30  IF(STOPRE(L).LT.STOMIN) GOTO 32
246      OUTRIP(L)=QIN(L)
247      IF(L.EQ.2.AND.LY.EQ.1) GOTO 33
248      IF(RIPAR(L).NE.O.AND.OUTRIP(L).LT.RIPARS(L)) KRIP(L)=KRIP(L)+1
249      IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.DEMANS(L))KDEM(L)=KDEM(L)+1
250      GOTO 34
251  33  IF(RIPAR(L).NE.O.AND.OUTRIP(L).LT.R299) KRIP(L)=KRIP(L)+1
252      IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.D299) KDEM(L)=KDEM(L)+1
253  34  SURPLU(L)=Q1-DEMAND(L)
254      GOTO 90
255  32  STOLI=STOPRE(L)-STOMIN
256      Q4=STOLI+Q1
257      IF(Q4.LT.O.O) GOTO 51
258      STOPRE(L)=STOPRE(L)+Q1
259      OUTRIP(L)=RIPAR(L)
260      Q2=Q.O-DEMAND(L)
261  CC
262  CC  SHORTAGE OF INFLOW, RELEASE FROM RESERVOIR TO MEET DEMAND
263  CC
264  31  STOLI=STOPRE(L)-STOMIN
265      Q5=STOLI+Q2
266      IF(Q5.LT.O.O) GOTO 52
267      STOPRE(L)=STOPRE(L)+Q2
268      OUTDEM(L)=DEMAND(L)
269      GOTO 90
270  CC
271  CC  EXCESS INFLOW TO BE PASSED
272  CC
273  40  SURPLU(L)=Q2
274      STOPRE(L)=STOMAX-STOICE(L)
275      GOTO 90
276  51  OUTRIP(L)=RIPAR(L)+Q4
277      IF(OUTRIP(L).LT.O.) OUTRIP(L)=O.
278      STOPRE(L)=STOMIN
279      OUTDEM(L)=O.O
280      SURPLU(L)=Q4-DEMAND(L)
281      IF(L.EQ.2.AND.LY.EQ.1) GOTO 53
282      IF(RIPAR(L).NE.O.AND.OUTRIP(L).LT.RIPARS(L)) KRIP(L)=KRIP(L)+1
283      IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.DEMANS(L))KDEM(L)=KDEM(L)+1
284      GOTO 55
285  53  IF(RIPAR(L).NE.O.AND.OUTRIP(L).LT.R299) KRIP(L)=KRIP(L)+1
286      IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.D299)KDEM(L)=KDEM(L)+1
287      GOTO 90
288  C
289  52  OUTDEM(L)=DEMAND(L)+Q5
290      IF(OUTDEM(L).LT.O.) OUTDEM(L)=O.
291      STOPRE(L)=STOMIN
292      SURPLU(L)=Q5
293      IF(L.EQ.2.AND.LY.EQ.1) GOTO 56
294      IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.DEMANS(L))KDEM(L)=KDEM(L)+1
295      GOTO 90
296  56  IF(DEMAND(L).NE.O.AND.UTDEM(L).LT.D299) KDEM(L)=KDEM(L)+1
297  CC
298  CC  DETERMINE PRESENT RES ELEV, SURFACE AREA, VOLUME
299  CC
300  90  STOLAS=STOPRE(L)+STOICE(L)
301      DSFLOW(L)=OUTRIP(L)+OUTDEM(L)+SURPLU(L)
302      IF(DSFLOW(L).LT.O.O) DSFLOW(L)=O.
303      DSFLOW(L)=DSFLOW(L)/(1.823E+NDAYS(L))
304  C
305      CALL LININT(ELPRE(L),AREPRE(L),STOLAS,MEL,RESEL,RESARE,RESVOL)
306      WRITE(7,205) L,STOPRE(L),STOICE(L),QIN(L),QINR(L),NET(L),
307      * OUTRIP(L),OUTDEM(L),OUTDIV(L),SURPLU(L),OUTSPI(L)
308  205  FORMAT(14,10F8.0)
309  C
310      ARELAS=AREPRE(L)
311  21  CONTINUE
312      WRITE(8,101) YEAR,(DSFLOW(J),J=1,12)
313      WRITE(8,208) YEAR,(ELPRE(J),J=1,12)
314  208  FORMAT(18,12F8.1)
315  2C  CONTINUE
316      WRITE(7,218)
317      FORMAT(//,'NUMBER OF TIMES:')
318      WRITE(7,219)
319  219  FORMAT(' IN SPILLWAY RIPARIAN DEMAND DIV.DEPEND')
320      WRITE(7,220)
321      FORMAT(' MONTH USED NOT MET NOT MET ON CANAL CAP.')
322      QD=9999.12
323      WRITE(7,221) K,KSPI(K),KRIP(K),KDEM(K),KDIV(K)
324  221  FORMAT(14,4I10)
325  99  CONTINUE
326  900  STOP
327      END
328      SUBROUTINE LININT(EL,ARE,STD,MEL,RESEL,RESARE,RESVOL)
329      DIMENSION RESEL(20),RESARE(20),RESVOL(20)
330  C
331      DO 2 I=1,MEL
332          X1=RESVOL(I)
333          X2=RESVOL(I+1)
334          IF(STD.GE.X1.AND.STD.LE.X2) GOTO 70
335  2  CONTINUE
336  CC
337  CC  INPUT DATA TOO LARGE - EXTRAPOLATE ABOVE RANGE
338      WRITE(7,300) STD
339  300  FORMAT(' STORAGE VOLUME GREATER THAN STOMAX:',F10.0)
340  CC
341  CC  CALCULATE RES AREA
342  CC
343  70  Y1=RESARE(I)
344      Y2=RESARE(I+1)
345      SLOPE=(Y2-Y1)/(X2-X1)
346      ARE=(STD-X2)*SLOPE+Y2
347  CC
348  CC  CALCULATE RES ELEVATION
349  CC
350      Y1=RESEL(I)
351      Y2=RESEL(I+1)
352      SLOPE=(Y2-Y1)/(X2-X1)
353      EL=(STD-X2)*SLOPE+Y2
354      RETURN
355      END

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```

241      51 IF (L.EQ.2 AND LY.EQ.1) GOTO 54
242      IF (RIPAR(L).NE.0 AND OUTRIP(L).LT.RIPAR(L)) KRIP(L)=KRIP(L)+1
243      GOTO 55
244      54 IF (RIPAR(L).NE.0 AND OUTRIP(L).LT.R299) KRIP(L)=KRIP(L)+1
245      55 STOPR(L)=STOMIN
246      OUTRIP(L)=RIPAR(L)+04
247      OUTSPI(L)=OUTSPI(L)+OUTRIP(L)
248      IF (L.EQ.2 AND LY.EQ.1) GOTO 58
249      IF (DEMAND(L).NE.0 AND OUTDEM(L).LT.DEMAN(L)) KDEM(L)=KDEM(L)+1
250      IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.DEMA2(L)) KDE2(L)=KDE2(L)+1
251      GOTO 57
252      56 IF (DEMAND(L).NE.0 AND OUTDEM(L).LT.D299) KDEM(L)=KDEM(L)+1
253      IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.D299) KDE2(L)=KDE2(L)+1
254      57 OUTDEM(L)=0
255      OUTDE2(L)=0
256      SURPLU(L)=04-DEMAND(L)-DEMAN2(L)
257      GOTO 50
258      52 IF (L.EQ.2 AND LY.EQ.1) GOTO 58
259      IF (DEMAND(L).NE.0 AND OUTDEM(L).LT.DEMAN(L)) KDEM(L)=KDEM(L)+1
260      IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.DEMA2(L)) KDE2(L)=KDE2(L)+1
261      GOTO 59
262      58 IF (DEMAND(L).NE.0 AND OUTDEM(L).LT.D299) KDEM(L)=KDEM(L)+1
263      IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.D299) KDE2(L)=KDE2(L)+1
264      59 STOPR(L)=STOMIN
265      OUTDEM(L)=DEMAND(L)+05
266      OUTSPI(L)=OUTSPI(L)+OUTDEM(L)
267      OUTDE2(L)=0
268      SURPLU(L)=05-DEMAND(L)
269      GOTO 50
270      53 IF (L.EQ.2 AND LY.EQ.1) GOTO 61
271      IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.DEMA2(L)) KDE2(L)=(2*L)+1
272      GOTO 62
273      61 IF (DEMAND(L).NE.0 AND OUTDE2(L).LT.D299) KDE2(L)=KDE2(L)+1
274      62 STOPR(L)=STOMIN
275      OUTDE2(L)=DEMAND(L)+07
276      OUTSPI(L)=OUTSPI(L)+OUTDE2(L)
277      SURPLU(L)=07-DEMAND(L)
278
279      CC
280      CC DETERMINE PRESENT RES ELEV, SURFACE AREA, VOLUME
281      CC
282      90 STGLAS=STOPR(L)+STOICE(L)
283      SYFLOW(L)=(OUTSPI(L)-OUTDE2(L))/(1.9835*NDAYS(L))
284      C
285      CALL LININT(ELPRE(L),AREPRE(L),STGLAS,NEL,RESEL,RESARE,RESVOL)
286      WRITE(7,205) L,STOPR(L),STOICE(L),OIN(L),CINR(L),NET(L),
287      * OUTRIP(L),OUTDEM(L),OUTDE2(L),SURPLU(L),OUTSPI(L)
288      205 FORMAT(14,10F8.0)
289      C
290      ARELAS=AREPRE(L)
291      21 CONTINUE
292      WRITE(6,101) YEAR,(SYFLOW(J),J=1,12)
293      WRITE(6,206) YEAR,(ELPRE(J),J=1,12)
294      206 FORMAT(15,12F8.1)
295      20 CONTINUE
296      WRITE(7,216)
297      216 FORMAT(1,/, 'NUMBER OF TIMES:')
298      WRITE(7,219)
299      219 FORMAT(1,/, 'IN SPILLWAY RIPARIAN DEMAND N.DEMAND')
300      WRITE(7,220)
301      220 FORMAT(1,/, 'MONTH USED NOT MET NOT MET NOT MET')
302      DO 50 K=1,12
303      WRITE(7,221) K,KSPI(K),KRIP(K),KDEM(K),KDE2(K)
304      221 FORMAT(14,4I10)
305      50 CONTINUE
306      500 STOP
307      END
308      SUBROUTINE LININT(EL,ARE,STO,NEL,RESEL,RESARE,RESVOL)
309      DIMENSION RESEL(20),RESARE(20),RESVOL(20)
310      C
311      DO 2 I=1,NEL
312      X1=RESVOL(I)
313      X2=RESVOL(I+1)
314      IF (STO GE X1 AND STO LE X2) GOTO 70
315      2 CONTINUE
316      CC
317      CC INPUT DATA TOO LARGE - EXTRAPOLATE ABOVE RANGE
318      300 FORMAT(1, 'STORAGE VOLUME GREATER THAN STOMAX:',F10.0)
319      CC
320      CC CALCULATE RES AREA
321      CC
322      70 Y1=RESARE(I)
323      Y2=RESARE(I+1)
324      SLOPE=(Y2-Y1)/(X2-X1)
325      ARE=(STO-X1)*SLOPE+Y1
326      CC
327      CC CALCULATE RES ELEVATION
328      CC
329      Y1=RESEL(I)
330      Y2=RESEL(I+1)
331      SLOPE=(Y2-Y1)/(X2-X1)
332      EL=(STO-X1)*SLOPE+Y1
333      RETURN
334      END

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End of File

APPENDIX C

Stations Used to Produce 5-Day Volumetric
Distribution of Streamflows Table C1

TABLE C1: STATIONS USED TO PRODUCE 6-DAY VOLUMETRIC DISTRIBUTION
OF STREAMFLOWS

YEAR	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1912	1	1	1	1	1	1	1	1	1	1	1	1
1913	4	4	4	4	1	1	1	1	1	1	4	4
1914	4	4	4	1	1	1	1	1	1	1	4	4
1915	4	4	4	1	1	1	1	1	1	1	1	1
1916	1	1	1	1	1	1	1	1	1	1	1	1
1917	1	1	1	1	1	1	1	1	1	1	1	1
1918	1	1	1	1	1	1	1	1	1	1	1	1
1919	1	1	1	1	1	1	1	1	1	1	1	1
1920	1	1	1	1	1	1	1	1	1	1	1	1
1921	1	1	1	1	1	1	1	1	1	1	1	1
1922	1	1	1	1	1	1	1	1	1	1	1	1
1923	1	1	1	1	1	1	1	1	1	1	4	4
1924	3	3	1	3	2	2	2	2	2	2	3	3
1925	3	3	2	2	2	2	2	2	2	2	3	3
1926	3	3	2	2	2	2	2	2	2	2	3	3
1927	3	3	2	2	2	2	2	2	2	2	3	3
1928	3	3	2	2	2	2	2	2	2	2	3	3
1929	3	3	2	2	2	2	2	2	2	2	3	3
1930	3	3	2	2	2	2	2	2	2	2	3	3
1931	3	3	2	2	3	3	3	4	4	4	4	4
1932	4	4	4	4	4	4	4	4	4	4	4	4
1933	5	5	5	5	5	5	5	5	5	5	5	5
1934	5	5	5	5	5	5	5	5	5	5	5	5
1935	5	5	5	2	2	2	2	2	2	2	5	5
1936	5	5	2	2	2	2	2	2	2	2	5	5
1937	5	5	2	2	2	2	2	2	2	2	5	5
1938	5	5	2	2	2	2	2	2	2	2	5	5
1939	5	5	2	2	2	2	2	2	2	2	5	5
1940	5	5	2	2	2	2	2	2	2	2	5	5
1941	5	5	2	2	2	2	2	2	2	2	5	5
1942	5	5	1	1	1	1	1	1	1	1	5	5
1943	5	5	1	1	1	1	1	1	1	1	5	5
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0

0 = WSC STATION 05A0021, WILLOW CREEK NEAR CLARESHOLM
1 = WSC STATION 05A0002, WILLOW CREEK NEAR HOLAN
2 = WSC STATION 05A0019, WILLOW CREEK NEAR GRAMM
3 = WSC STATION 05B0009, HIGHWOOD RIVER NEAR ALDENBYDE
4 = WSC STATION 05B0001, ELBOW RIVER BELOW GLENMORE DAM
5 = WSC STATION 05B0005, ELBOW RIVER ABOVE GLENMORE DAM
6 = WSC STATION 05A0003, LEE CREEK AT CARDRYN